

PHYSICS



EXAM QUESTION PACK

4 FORCES, DENSITY AND PRESSURE

SCORE

/

PERCENTAGE

%

STEMUP

These questions belong to CIE, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by Cambridge International (CIE). They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with CIE and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. CIE has not endorsed, approved or been involved in the production of it. CIE and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

CIE publishes its past papers, mark schemes and examiner reports. Always check the current syllabus at [cambridgeinternational.org](https://www.cambridgeinternational.org) before you revise.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Chapter 5

Forces, density and pressure

5.1 Types of force

364. 9702_m20_qp_12 Q: 11

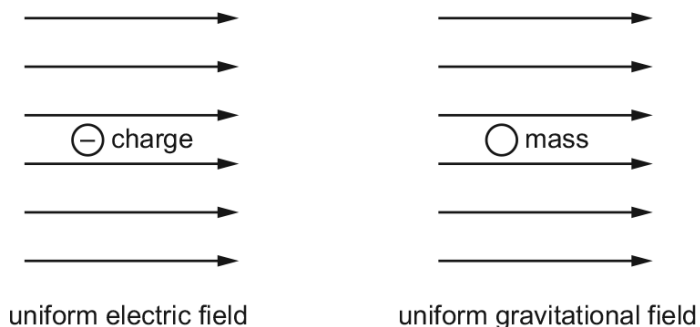
A particle is in a uniform field. The particle experiences a force in the opposite direction to the field.

In which type of field is the particle, and on which property of the particle is the field acting?

	type of field	property of particle on which the field acts
A	electric	charge
B	electric	current
C	gravitational	mass
D	gravitational	weight

365. 9702_s20_qp_12 Q: 10

The diagrams show a negative electric charge situated in a uniform electric field and a mass situated in a uniform gravitational field.



Which row shows the directions of the forces acting on the charge and on the mass?

	charge	mass
A		
B		
C		
D		

366. 9702_m19_qp_12 Q: 11

A ball falls through a liquid at a constant speed. It is acted upon by three forces: an upthrust, a drag-force and its weight.

Which statement is correct?

- A** The drag-force increases with increasing depth.
- B** The drag-force is equal to the sum of the upthrust and weight.
- C** The upthrust is constant with increasing depth.
- D** The weight is greater than the sum of the drag-force and the upthrust.

367. 9702_s19_qp_12 Q: 12

A submarine descends vertically at constant velocity. The three forces acting on the submarine are viscous drag, upthrust and weight.

Which relationship between their magnitudes is correct?

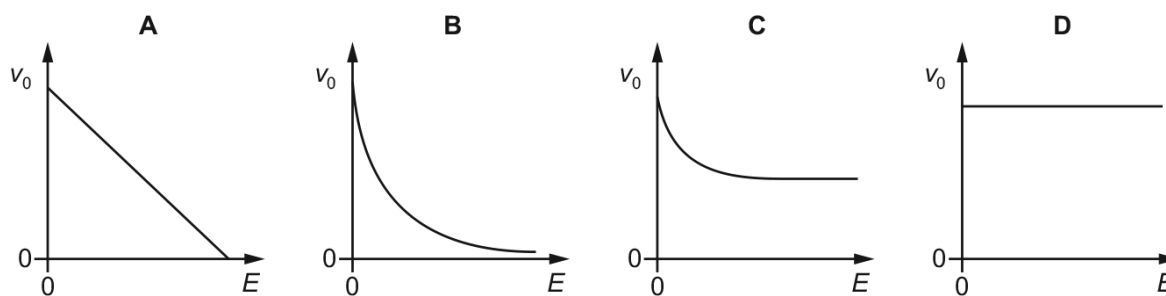
- A** weight < drag
- B** weight = drag
- C** weight < upthrust
- D** weight > upthrust

368. 9702_w19_qp_12 Q: 10

A positively charged oil droplet falls in air in a uniform electric field that is vertically upwards. The droplet has a constant terminal speed v_0 and the electric field strength is E .

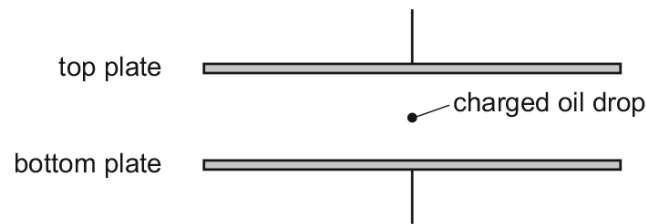
The magnitude of the force due to air resistance acting on the droplet is proportional to the speed of the droplet.

Which graph shows the variation with E of v_0 ?



369. 9702_m18_qp_12 Q: 12

A charged oil drop is held stationary between two charged parallel plates.



Which forces act on the oil drop?

- A** both electric and gravitational
- B** electric only
- C** gravitational only
- D** neither electric nor gravitational

370. 9702_s18_qp_12 Q: 11

An astronaut throws a stone horizontally near to the surface of the Moon, where there is no atmosphere.

Which row describes the horizontal and vertical forces acting on the stone after release?

	horizontal force	vertical force
A	non-zero and constant	constant
B	non-zero and constant	decreasing
C	zero	constant
D	zero	decreasing

371. 9702_w18_qp_11 Q: 10

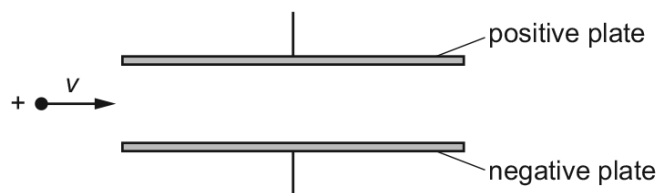
A charged particle is placed in a uniform field of force. The direction of the force on the particle is opposite to the direction of the field.

What is the field and what is the charge on the particle?

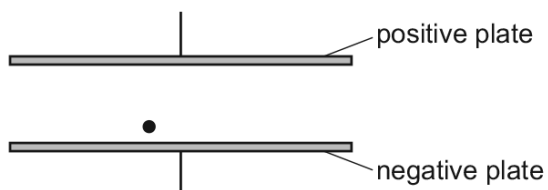
	field	charge on particle
A	electric	negative
B	electric	positive
C	gravitational	negative
D	gravitational	positive

372. 9702_w18_qp_12 Q: 11

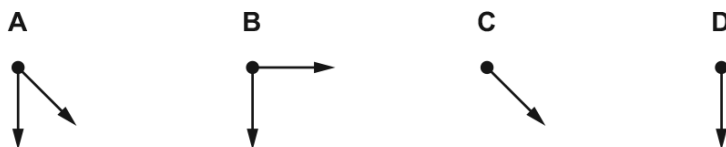
A positively-charged particle of negligible mass, moving at constant velocity v in a vacuum, enters a uniform electric field between two parallel plates, as shown.



A short time later, the particle is at the position shown.



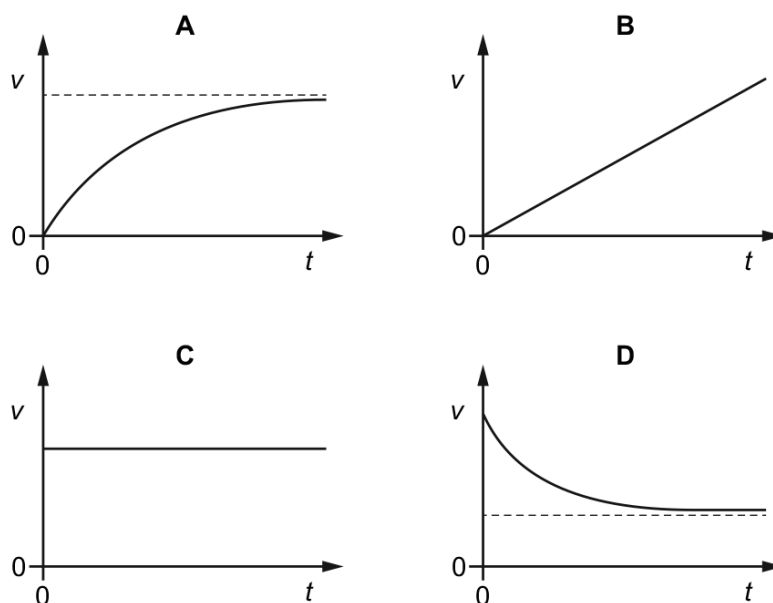
Which diagram represents the force or forces acting on the particle?



373. 9702_w18_qp_13 Q: 11

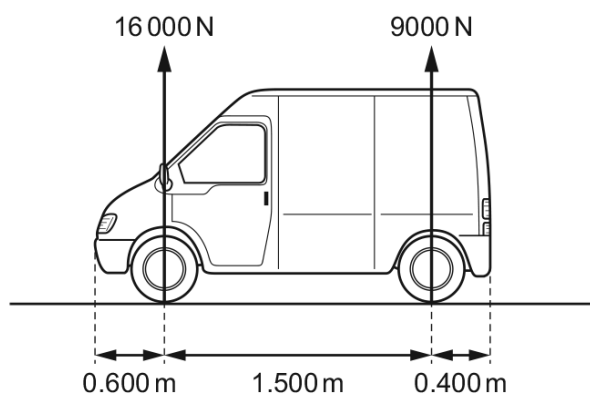
A rigid, hollow sphere is immersed deep in water and released from rest. It experiences an upthrust which propels it towards the surface of the water.

Which graph best shows the variation with time t of its upward velocity v ?



374. 9702_m17_qp_12 Q: 13

The vertical forces that the ground exerts on a stationary van are shown.



The van is 2.50 m long with the wheels at a distance of 0.600 m from the front of the van and 0.400 m from the rear of the van.

What is the horizontal distance of the van's centre of gravity from the front of the van?

- A** 0.540 m **B** 0.960 m **C** 1.14 m **D** 1.36 m

375. 9702_m17_qp_12 Q: 15

Which force is caused only by a pressure difference?

- A** friction
- B** upthrust
- C** viscous force
- D** weight

376. 9702_s17_qp_11 Q: 11

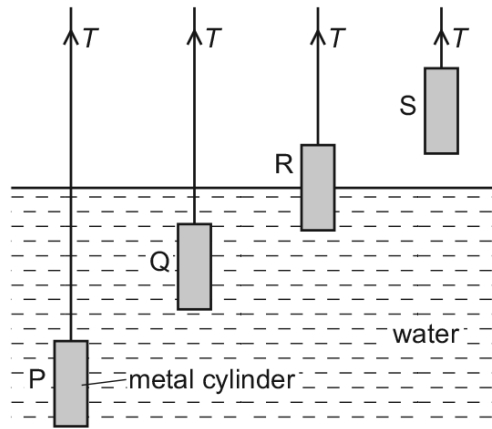
A particle with mass and charge is moving from left to right in a uniform gravitational field and a uniform electric field. The gravitational field is downwards. The gravitational force and the electric force on this particle act in opposite directions.

What could be the sign of the charge on the particle and the direction of the electric field?

	sign of charge	direction of electric field
A	negative	down
B	negative	up
C	positive	left
D	positive	right

377. 9702_s17_qp_12 Q: 10

A metal cylinder is suspended vertically in equilibrium by a cord. The diagram shows the cylinder in four different positions P, Q, R and S.



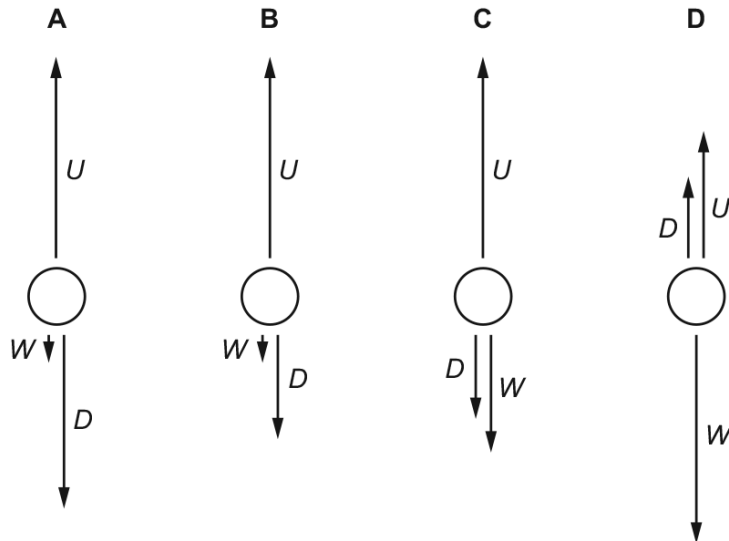
Which statement explains the variation of the tension T in the cord?

- A** At P and at Q, the tension T in the cord is the same because the difference in pressure between the top and bottom of the cylinder is the same.
 - B** At Q, the tension T in the cord is less than at P because, at smaller depth, liquid pressure is smaller.
 - C** At R, the tension T in the cord is less than at P because atmospheric pressure is less than water pressure.
 - D** At S, the tension T in the cord is greater than at P because atmospheric pressure at S exerts no force on the top or bottom of the cylinder.
-

378. 9702_s17_qp_13 Q: 12

An air bubble is rising through a liquid at a constant speed. The forces on it are the upthrust U , the viscous drag D and its weight W .

Which diagram shows the directions and relative sizes of the forces?



379. 9702_w17_qp_11 Q: 8

The three forces acting on a hot-air balloon that is moving vertically are its weight, the force due to air resistance and the upthrust force.

The hot-air balloon descends vertically at constant speed. The force of air resistance on the balloon is F .

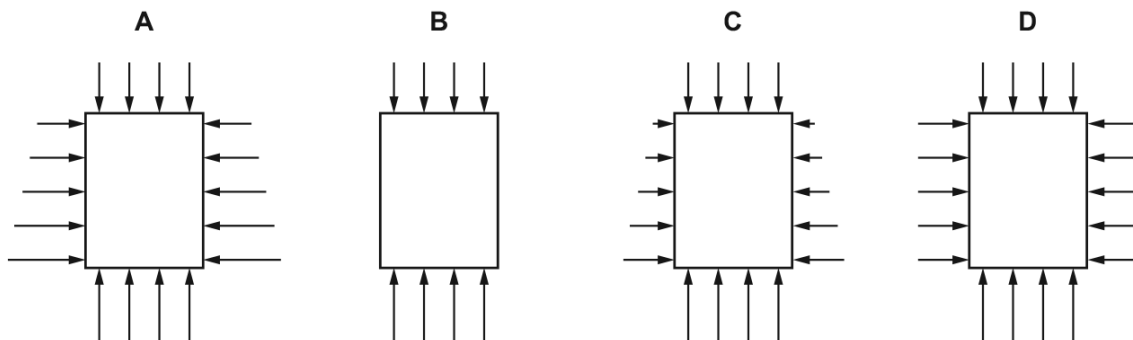
Which weight of material must be released from the balloon so that it ascends vertically at the same constant speed?

- A** F **B** $2F$ **C** $3F$ **D** $4F$

380. 9702_w17_qp_11 Q: 12

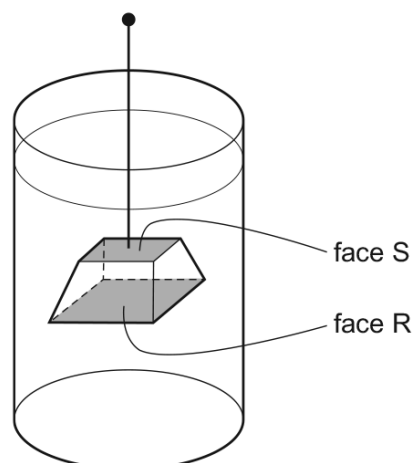
A block is submerged vertically in a liquid. The four diagrams show, to scale, the forces exerted by the liquid on the block.

Which diagram correctly shows a possible situation as viewed from the side?



381. 9702_w17_qp_12 Q: 11

The diagram shows a block of copper suspended in water.



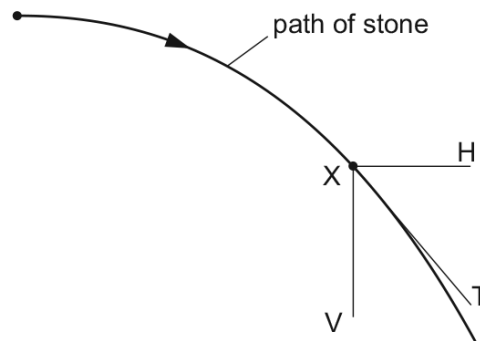
The block experiences an upthrust from the water.

Which statement is the basis of an explanation for this upthrust?

- A** Copper is more dense than water.
- B** The area of face R is greater than the area of face S.
- C** The density of water increases with depth.
- D** The pressure of water increases with depth.

382. 9702_w17_qp_13 Q: 11

A stone is projected horizontally in a vacuum and moves along the path shown.



X is a point on this path. XV and XH are vertical and horizontal lines respectively through X. XT is the tangent to the path at X.

Along which directions do forces act on the stone at X?

- A** XV and XH **B** XV only **C** XH only **D** XT only

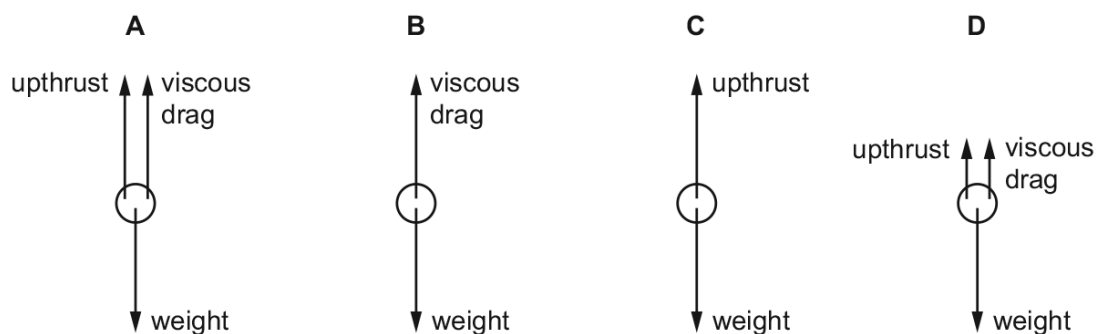
383. 9702_s16_qp_13 Q: 13

What is the centre of gravity of an object?

- A** the geometrical centre of the object
B the point at which the weight of the object may be considered to act
C the point on the object about which there is a zero net torque
D the point where gravity acts on the object

384. 9702_w16_qp_12 Q: 14

Which diagram best shows the forces acting on a ball falling at a constant velocity through a liquid?



385. 9702_s15_qp_12 Q: 12

An astronaut throws a stone with a horizontal velocity near to the Moon's surface.

Which row describes the horizontal and vertical forces acting on the stone after release?

	horizontal force	vertical force
A	constant	constant
B	constant	decreasing
C	zero	constant
D	zero	decreasing

5.2 Turning effects of forces

386. 9702_m20_qp_12 Q: 12

A uniform rod of weight 20 N and length 2.0 m is acted upon by two vertical forces, as shown.



What are the resultant force acting on the rod and the resultant moment about the centre of gravity of the rod?

	resultant force /N	resultant moment /Nm
A	0	10
B	0	20
C	20	10
D	20	20

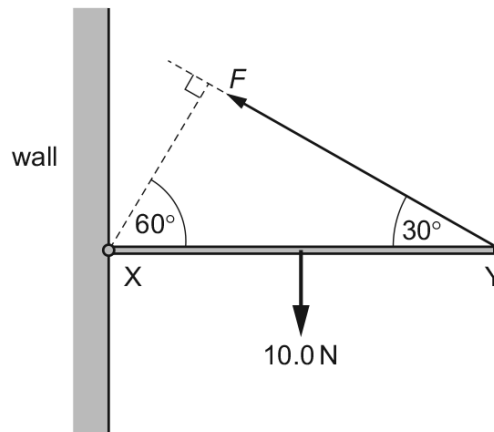
387. 9702_s20_qp_11 Q: 12

Which statement best describes a couple?

- A** a pair of forces of equal magnitude acting in opposite directions which produce rotational motion but not translational motion
- B** a pair of forces of equal magnitude acting in opposite directions which produce translational motion but not rotational motion
- C** a pair of forces of equal magnitude acting in the same direction which produce rotational motion but not translational motion
- D** a pair of forces of equal magnitude acting in the same direction which produce translational motion but not rotational motion

388. 9702_s20_qp_11 Q: 13

A uniform rod XY of weight 10.0 N is freely hinged to a wall at X. It is held horizontal by a force F acting from Y at an angle of 30° to the horizontal, as shown.

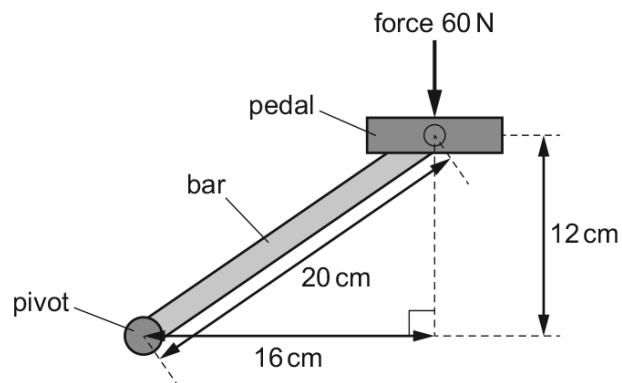


What is the value of F ?

- A** 5.0 N **B** 8.7 N **C** 10.0 N **D** 20.0 N

389. 9702_s20_qp_12 Q: 11

A bicycle pedal is connected to a pivot by a metal bar, as shown.



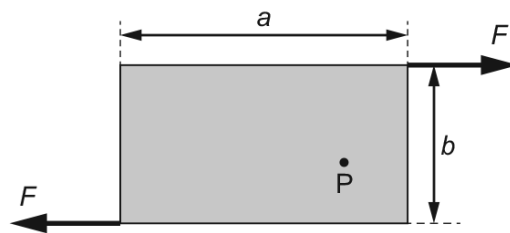
The force on the pedal is 60 N downwards.

What is the moment of this force about the pivot?

- A** 7.2 Nm **B** 9.6 Nm **C** 12 Nm **D** 1200 Nm

390. 9702_s20_qp_13 Q: 12

Two forces, each of magnitude F , act along the edges of a rectangular metal plate, as shown.



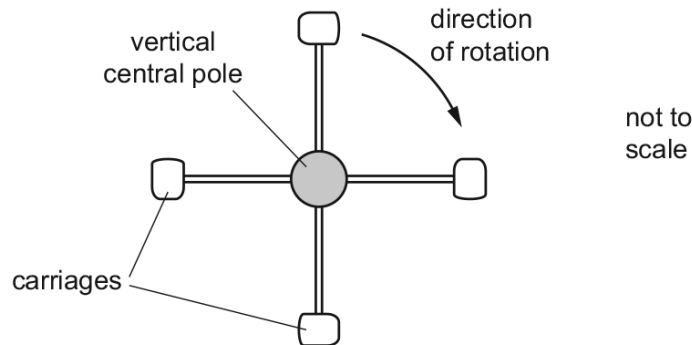
The plate has length a and width b .

What is the torque about point P?

- A** Fa **B** Fb **C** $2Fa$ **D** $2Fb$

391. 9702_m19_qp_12 Q: 12

A fairground ride consists of four carriages connected to a central vertical pole, as shown in the following view from above.



A motor rotates the central pole about its axis. This results in the four carriages each moving along a circular path.

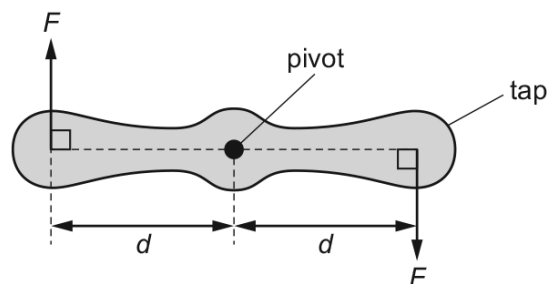
The distance from the middle of each carriage to the centre of the pole is 3.20 m. When they are moving, each carriage experiences an air resistance force of 85.0 N. Assume that there are no other significant resistive forces.

Which torque does the motor need to apply to the pole to keep the system rotating at constant maximum speed?

- A** 5.44 Nm **B** 272 Nm **C** 544 Nm **D** 1090 Nm

392. 9702_s19_qp_11 Q: 13

A couple is applied to a tap as shown.

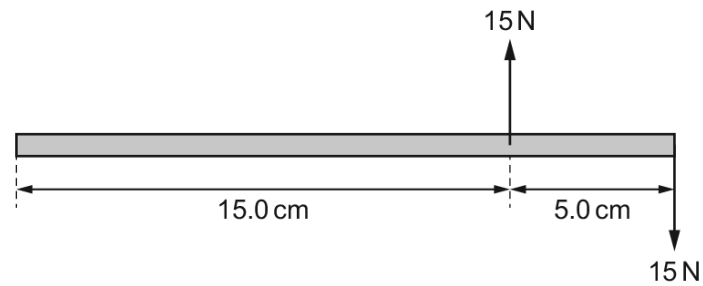


What is the torque of the couple?

- A** $\frac{Fd}{2}$ **B** Fd **C** $2Fd$ **D** $4Fd$

393. 9702_s19_qp_13 Q: 13

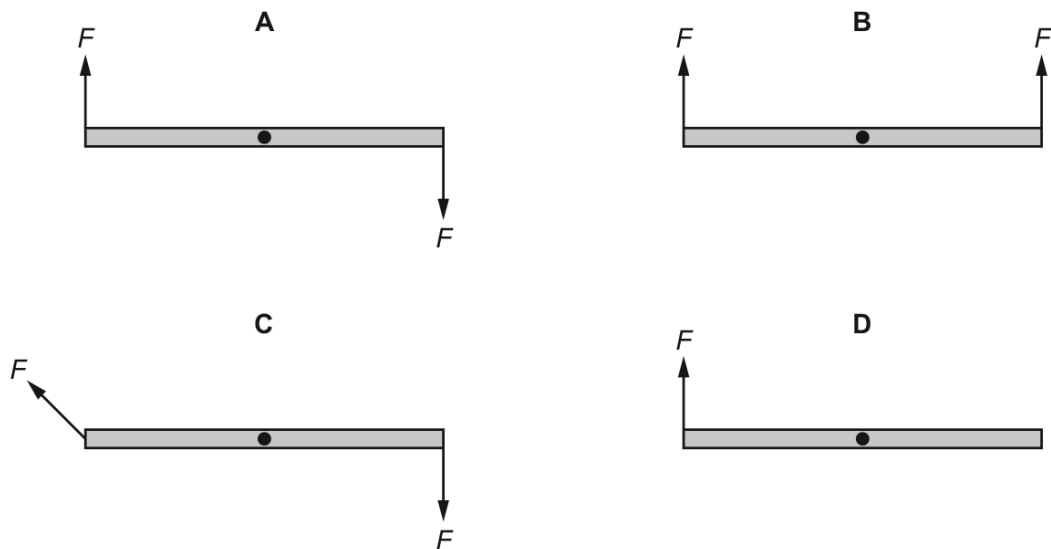
What is the torque of the couple shown?



- A** 0.75 Nm **B** 1.50 Nm **C** 3.00 Nm **D** 5.25 Nm

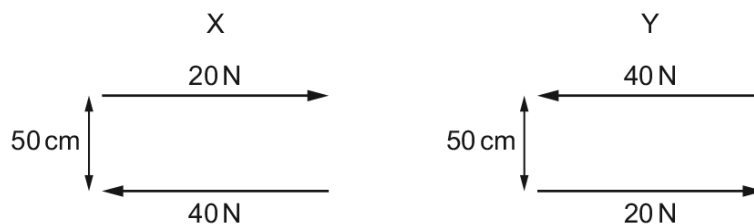
394. 9702_w19_qp_11 Q: 12

Which diagram shows a couple?



395. 9702_w19_qp_13 Q: 11

The diagram shows two pairs X and Y of parallel forces.

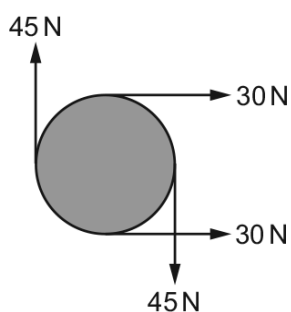


Which statement is correct?

- A** X is equivalent to a clockwise torque of 10 N m and a force of 20 N to the left.
- B** X is equivalent to a clockwise torque of 20 N m only.
- C** Y is equivalent to an anticlockwise torque of 30 N m and a force of 20 N to the left.
- D** Y is equivalent to an anticlockwise torque of 30 N m only.

396. 9702_m18_qp_12 Q: 11

The diagram shows four forces applied to a circular object.

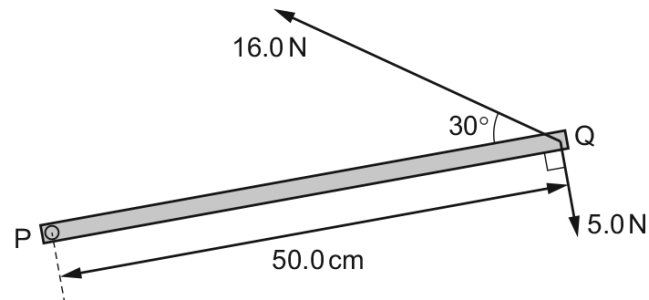


Which row describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
A	non-zero	non-zero
B	non-zero	zero
C	zero	non-zero
D	zero	zero

397. 9702_s18_qp_11 Q: 10

A horizontal metal bar PQ of length 50.0 cm is hinged at end P. The diagram shows the metal bar viewed from above.



Two forces of 16.0 N and 5.0 N are in the horizontal plane and act on end Q as shown in the diagram.

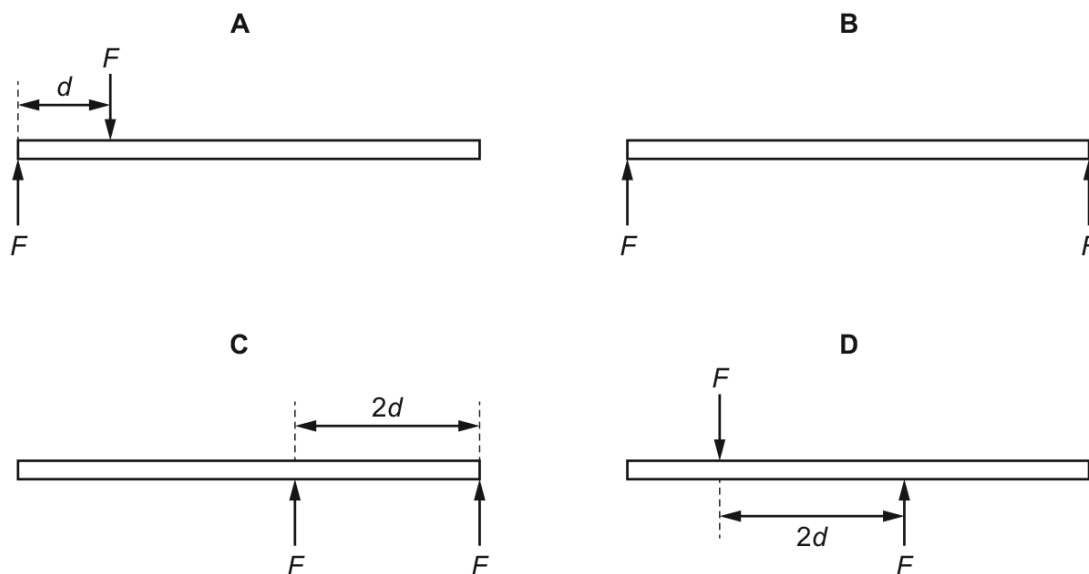
What is the total moment about P due to the two forces?

- A** 1.5 Nm **B** 4.4 Nm **C** 6.5 Nm **D** 9.4 Nm

398. 9702_s18_qp_11 Q: 12

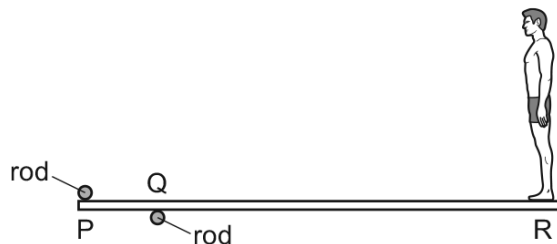
Two parallel forces, each of magnitude F , act on a rod of length $5d$.

Which diagram shows the positions of the two forces that will produce the largest torque on the rod?



399. 9702_s18_qp_12 Q: 13

A uniform diving-board is held by two fixed rods at points P and Q. A person stands at end R of the diving-board, as shown.



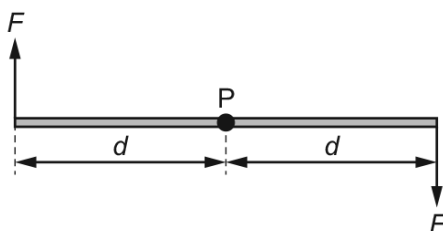
The forces exerted by the rods on the board are vertical. The board remains in equilibrium as the person slowly moves towards point Q from end R.

Which row describes the changes to the forces exerted by the rods on the board?

	force at P	force at Q
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

400. 9702_s18_qp_12 Q: 14

Two forces, each of magnitude F , act in opposite directions on a rod.



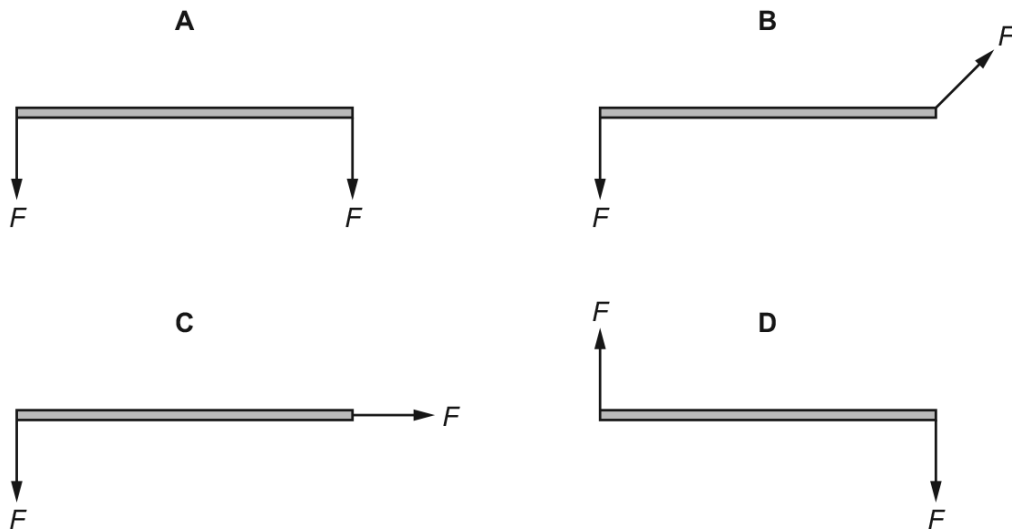
Each force acts on the rod at a distance d from the pivot P.

What is the torque of this couple about P?

- A** 0 **B** $F \times d$ **C** $2F \times d$ **D** $2F \times 2d$

401. 9702_s18_qp_13 Q: 12

Which diagram shows a couple formed by two forces, each of magnitude F , acting on a rod?

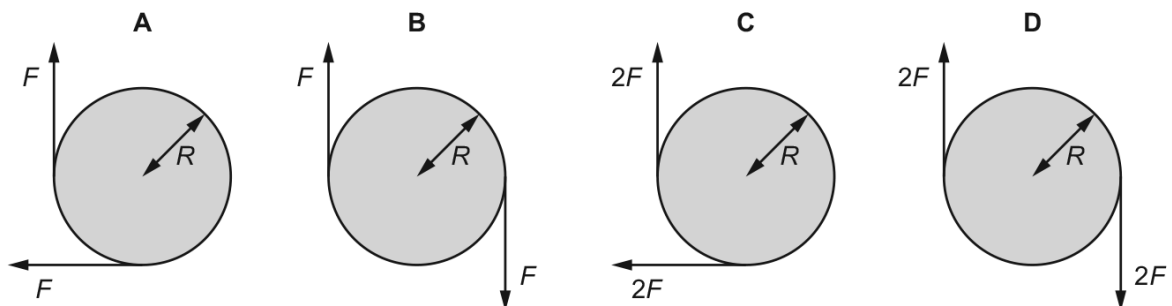


402. 9702_w18_qp_13 Q: 12

A flat metal disc has radius R .

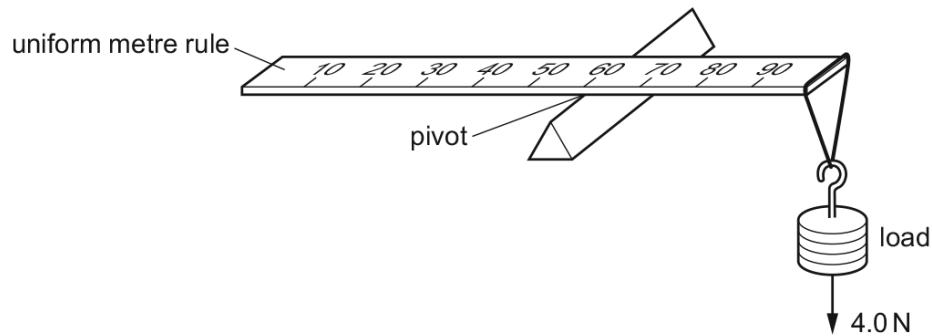
Forces of magnitude F are applied tangentially at the edge of the disc. The forces are in the plane of the disc.

Which arrangement of forces produces only a torque of magnitude $2FR$?



403. 9702_m17_qp_12 Q: 12

A uniform metre rule of weight 2.0 N is pivoted at the 60 cm mark. A 4.0 N load is suspended from one end, causing the rule to rotate about the pivot.



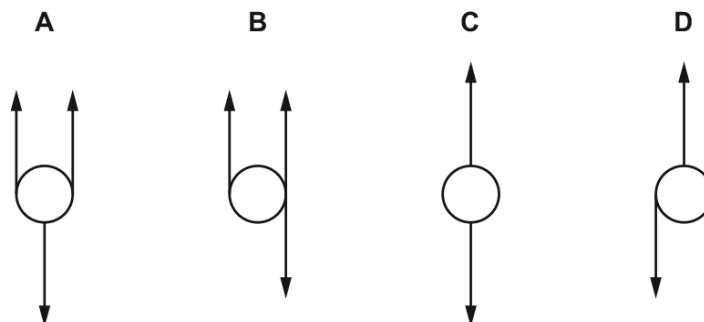
At the instant when the rule is horizontal, what is the resultant moment about the pivot?

- A** 0.0 Nm **B** 1.4 Nm **C** 1.6 Nm **D** 1.8 Nm

404. 9702_s17_qp_11 Q: 12

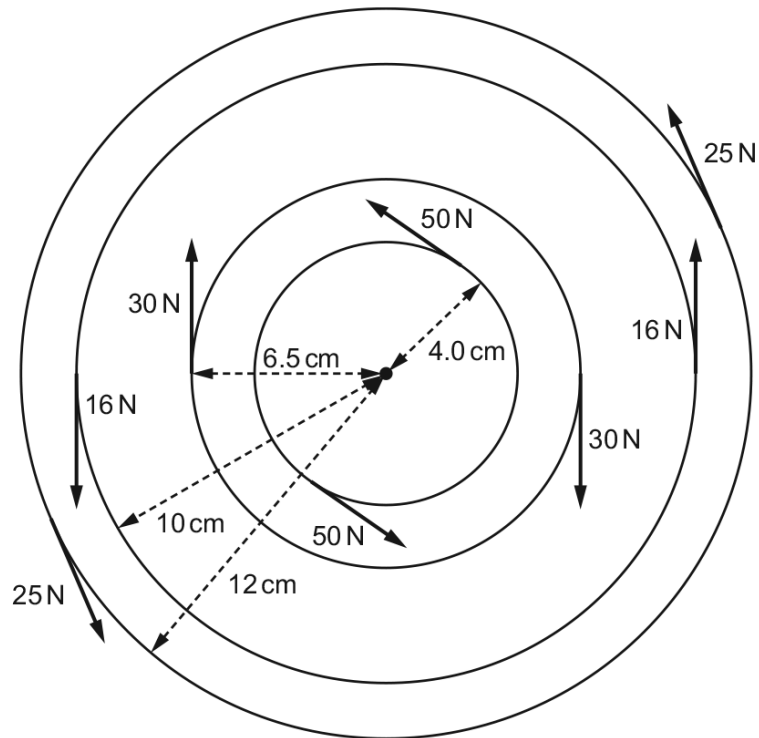
A sphere is acted upon by various forces, all of the same magnitude.

Which system of forces provides a resultant torque but zero resultant force on the sphere?



405. 9702_s17_qp_12 Q: 11

In a machine, many couples act on a rotating object as shown.



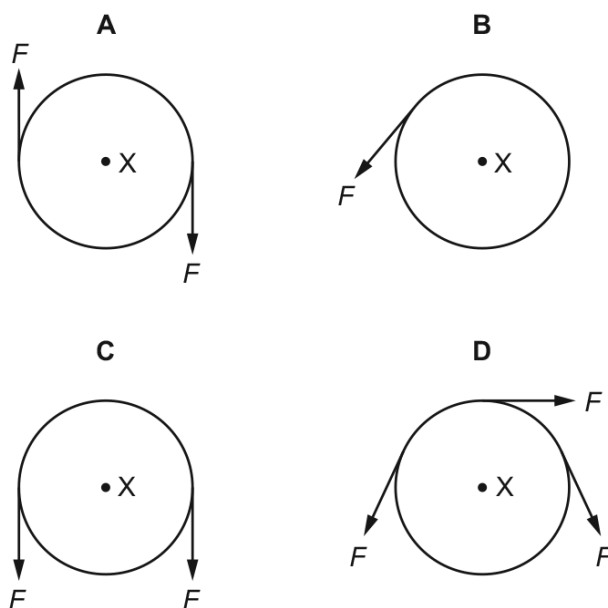
What is the resultant torque acting on the rotating object?

- A** 4.7 Nm **B** 8.6 Nm **C** 9.3 Nm **D** 17.1 Nm
-

406. 9702_w17_qp_11 Q: 13

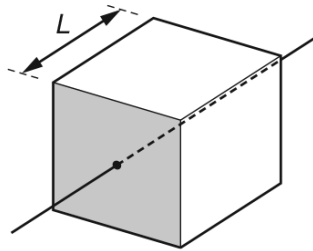
A rigid circular disc of radius r has its centre at X . A number of forces of equal magnitude F act at the edge of the disc. All the forces are in the plane of the disc.

Which arrangement of forces provides a moment of magnitude $2Fr$ about X ?

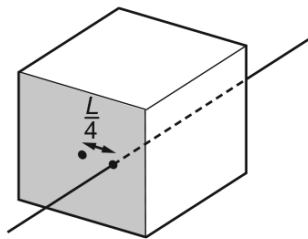


407. 9702_w17_qp_12 Q: 12

The diagram shows a solid cube with weight W and sides of length L . It is supported at rest by a frictionless spindle that passes through the centres of two opposite vertical faces. One of these faces is shaded.



The spindle is now removed and replaced at a distance $\frac{L}{4}$ to the right of its original position.

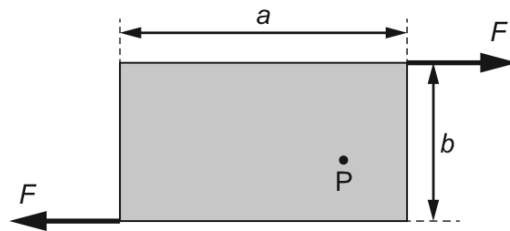


When viewing the shaded face, what is the torque of the couple that will now be needed to keep the cube at rest?

- A $\frac{WL}{4}$ anticlockwise
- B $\frac{WL}{4}$ clockwise
- C $\frac{WL}{2}$ anticlockwise
- D $\frac{WL}{2}$ clockwise

408. 9702_w17_qp_13 Q: 12

Two forces, each of magnitude F , act along the edges of a rectangular metal plate, as shown.



The plate has length a and width b .

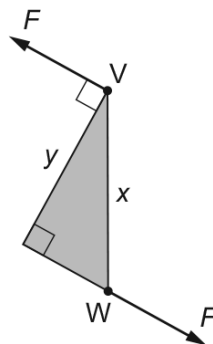
What is the torque about point P?

- A** Fa **B** Fb **C** $2Fa$ **D** $2Fb$

409. 9702_m16_qp_12 Q: 13

Two forces, each of magnitude F , act at points V and W on an object.

The two forces form a couple. The shape of the object is a right-angled triangle with sides of lengths x and y , as shown.



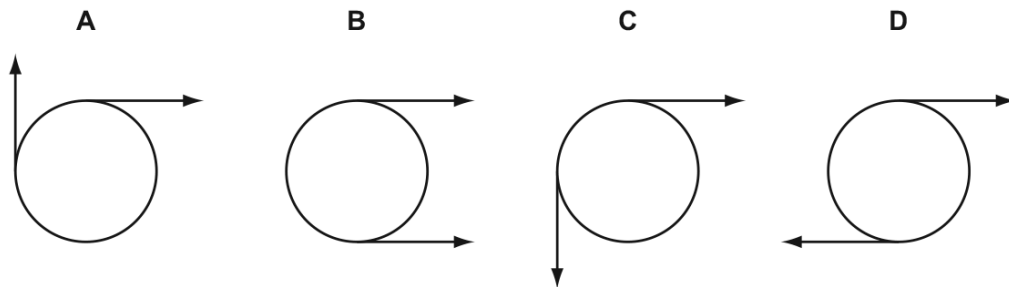
Which expression gives the torque exerted by the couple?

- A** Fx **B** Fy **C** $2Fx$ **D** $2Fy$

410. 9702_s16_qp_12 Q: 14

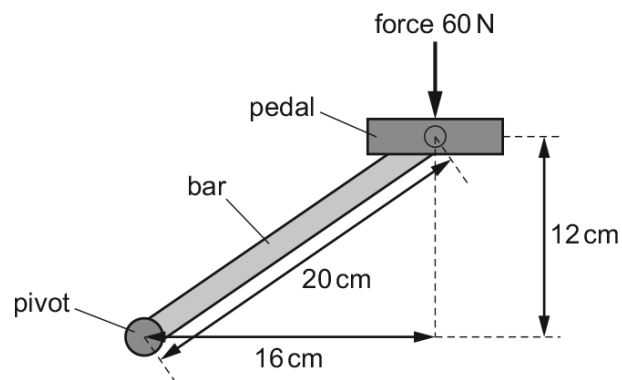
Two coplanar forces act on the rim of a wheel. The forces are equal in magnitude.

Which arrangement of forces provides only a couple?



411. 9702_s16_qp_13 Q: 14

A bicycle pedal is connected to a pivot by a metal bar, as shown.



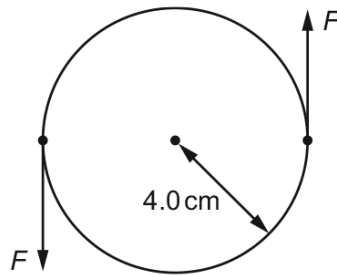
The force on the pedal is 60 N downwards.

What is the moment of this force about the pivot?

- A** 7.2 Nm **B** 9.6 Nm **C** 12 Nm **D** 1200 Nm

412. 9702_w16_qp_12 Q: 15

A minimum torque of 20 Nm must be applied to the lid of a jar for it to open. The radius of the lid is 4.0 cm .

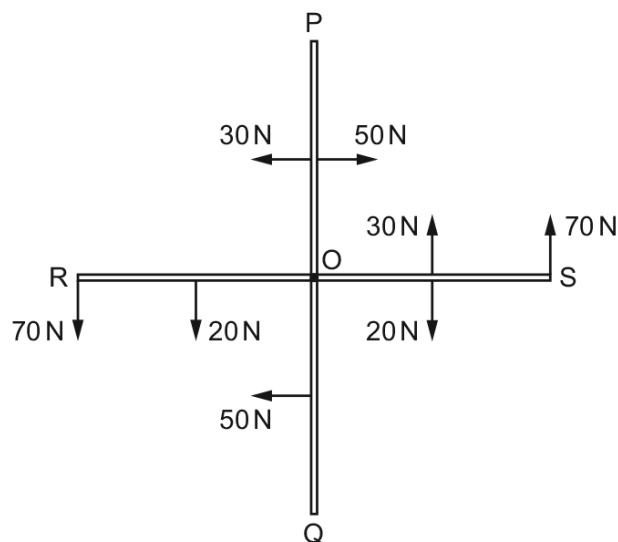


What is the minimum force F that must act on each side of the lid in order to open it?

- A** 2.5 N **B** 5.0 N **C** 250 N **D** 500 N

413. 9702_w16_qp_12 Q: 17

A rigid cross-shaped structure having four arms PO, SO, QO and RO, each 1.00 m long, is pivoted at O. Forces act on the ends of the arms and on the midpoints of the arms as shown.



What is the magnitude of the resultant moment on the structure about O?

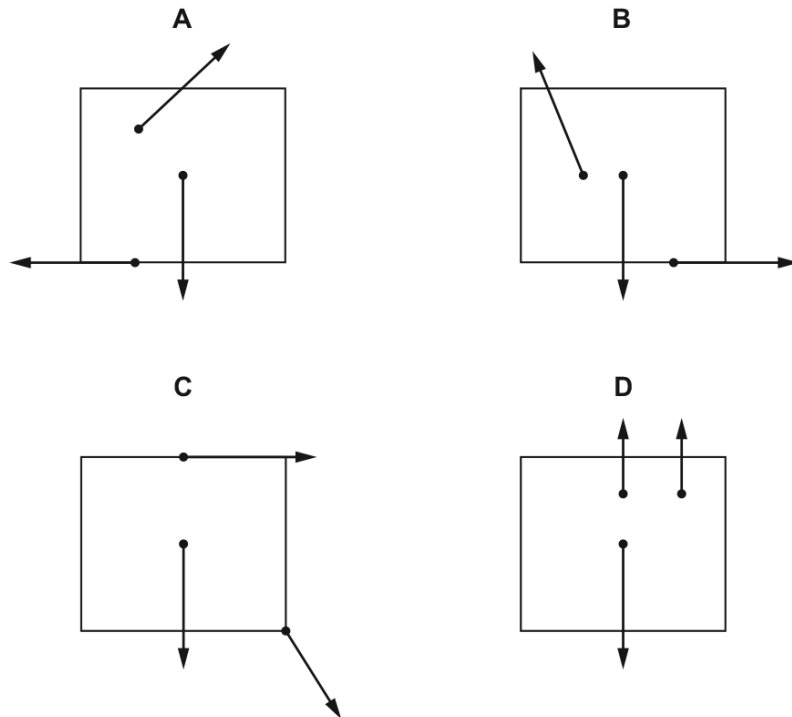
- A** 45 Nm **B** 90 Nm **C** 120 Nm **D** 190 Nm

5.3 Equilibrium of forces

414. 9702_m20_qp_12 Q: 13

Three coplanar forces act on a block.

Which diagram shows the directions of the forces such that the block could be in equilibrium?

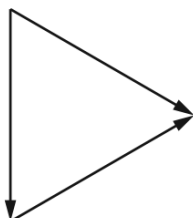
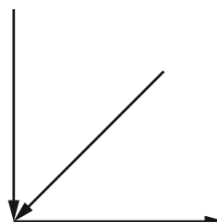
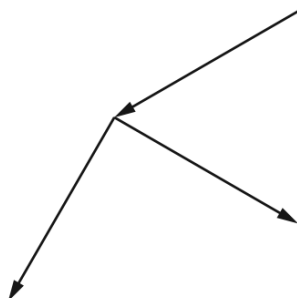
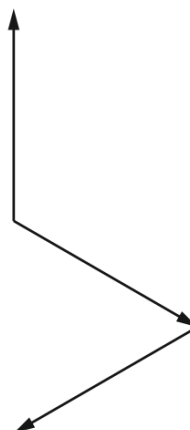


415. 9702_s20_qp_11 Q: 14

Four combinations of vectors are shown, each representing all the forces acting on an object. The forces all act in the same plane.

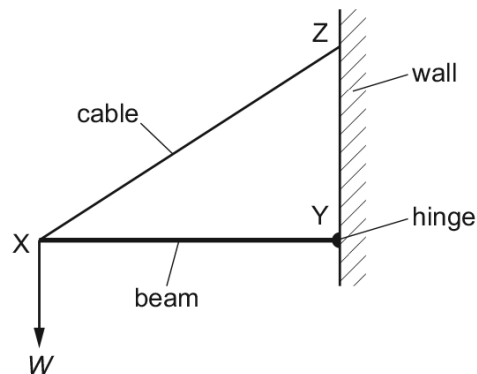
The object is in equilibrium.

Which combination of vectors could represent the forces acting on the object?

A**B****C****D**

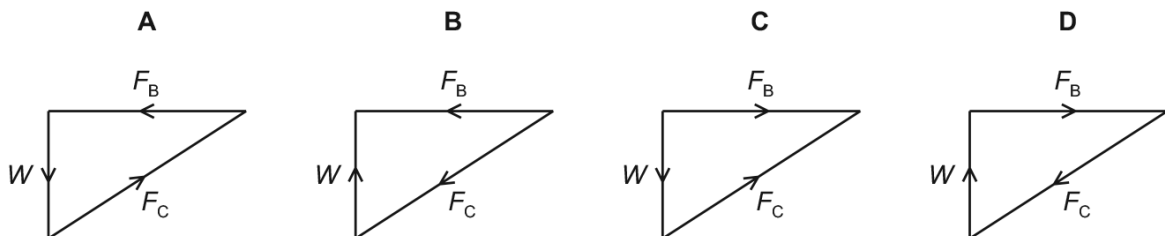
416. 9702_s20_qp_12 Q: 12

A thin horizontal beam XY is freely hinged at point Y to a vertical wall. The beam is held stationary by a cable XZ which is attached to the wall at point Z.



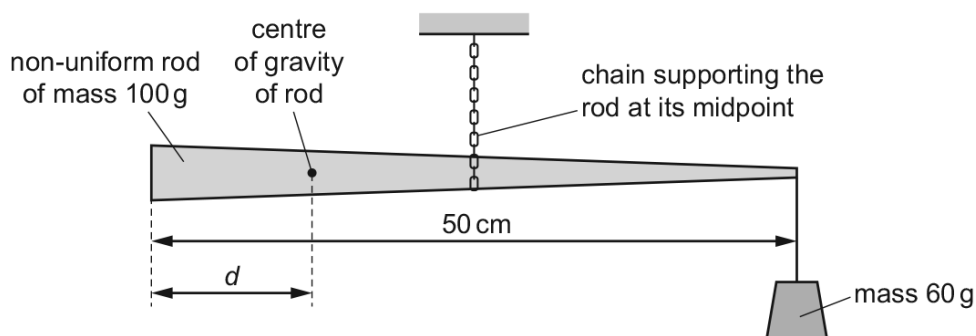
The beam supports a weight W at point X. The forces in the cable and the beam are F_C and F_B respectively.

Which vector triangle represents the forces acting on point X?



417. 9702_s20_qp_13 Q: 13

A non-uniform rod has a mass of 100 g and a length of 50 cm. It is supported by a chain at its midpoint. The rod is held in equilibrium by having a mass of 60 g suspended from its right-hand end, as shown.



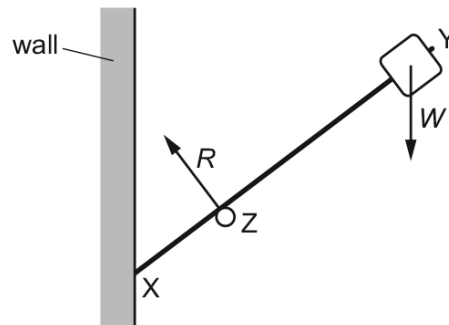
The centre of gravity of the rod is a distance d from its left-hand end.

What is the value of d ?

- A** 10 cm **B** 15 cm **C** 25 cm **D** 40 cm

418. 9702_s20_qp_13 Q: 14

A light rigid rod XY has an object of weight W fixed at one end. The rod is in equilibrium, resting on a support at Z and a vertical wall at X . The support exerts a force R on the rod as shown. The diagram shows the directions, but not the magnitudes, of the forces R and W .

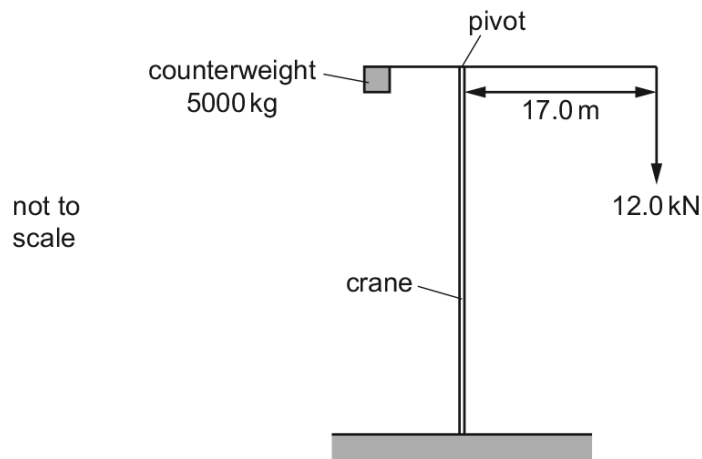


What is the direction of the force on the rod at X ?



419. 9702_s19_qp_11 Q: 14

A crane uses a counterweight to stop it from toppling over when lifting a load, as shown.



The counterweight has a mass of 5000 kg. The crane is required to lift a load of 12.0 kN and the horizontal distance from the pivot to the load is 17.0 m.

How far from the pivot should the centre of gravity of the counterweight be positioned in order to keep the crane in equilibrium?

- A** 0.0408 m **B** 0.240 m **C** 4.16 m **D** 40.8 m

420. 9702_s19_qp_11 Q: 15

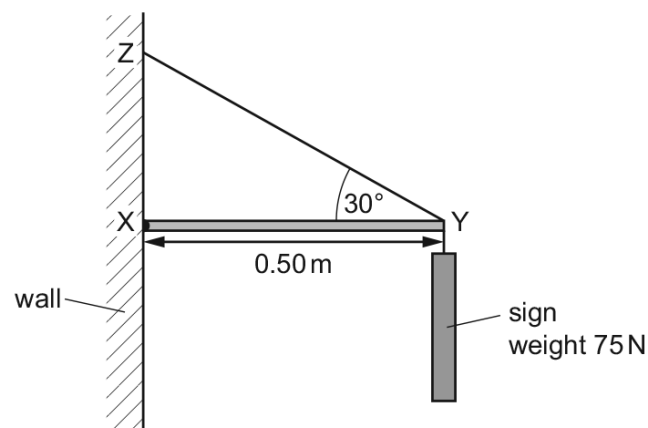
Three parallel forces act on an object. As a result of these forces, the object is in equilibrium.

What **must** be correct for these forces?

- A They all act along the same line.
- B They all have the same magnitude.
- C They do **not** all act along the same line.
- D They do **not** all have the same magnitude.

421. 9702_s19_qp_13 Q: 12

A shop sign weighing 75 N hangs from a frame attached to a vertical wall.



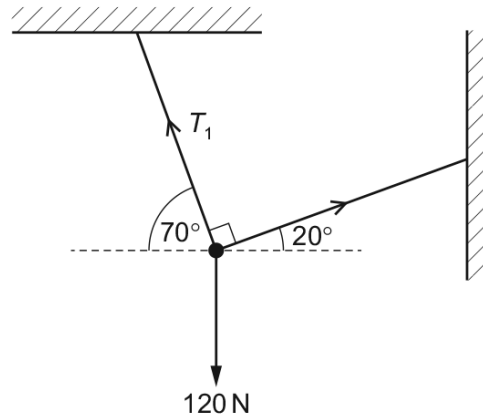
The frame consists of a horizontal rod XY and a rod YZ that is at an angle of 30° to the horizontal. Rod XY is attached to the wall by a hinge at X and has length 0.50 m. Assume that the weights of the rods are negligible.

What is the horizontal force exerted by the wall on rod XY?

- A 0 N
- B 43 N
- C 130 N
- D 150 N

422. 9702_w19_qp_11 Q: 13

An object of weight 120 N is supported in equilibrium by two strings as shown.

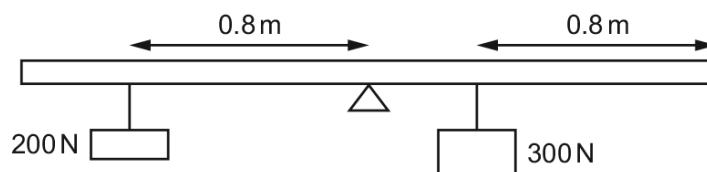


What is the tension T_1 in the left-hand string?

- A** 41 N **B** 77 N **C** 113 N **D** 128 N

423. 9702_w19_qp_12 Q: 11

A rigid uniform bar of length 2.4 m is pivoted horizontally at its midpoint.



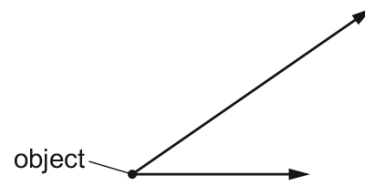
Weights are hung from two points on the bar as shown in the diagram. To maintain equilibrium, a couple is applied to the bar.

What is the torque and direction of this couple?

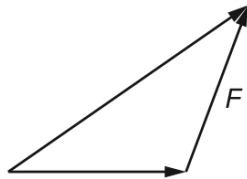
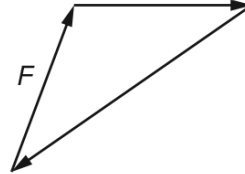
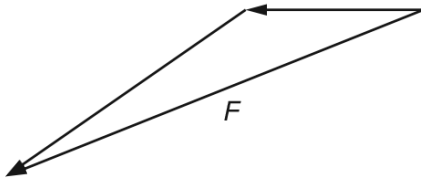
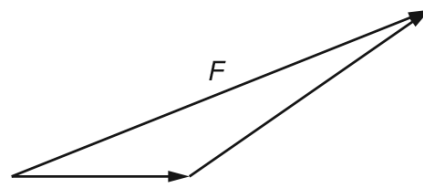
- A** 40 N m clockwise
B 40 N m anticlockwise
C 80 N m clockwise
D 80 N m anticlockwise

424. 9702_w19_qp_12 Q: 12

Two coplanar forces act on an object as shown.

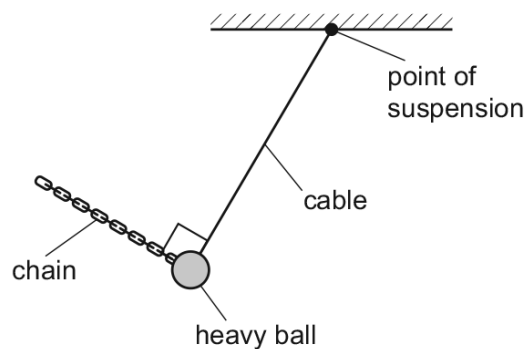


Which diagram shows the resultant F of these two forces?

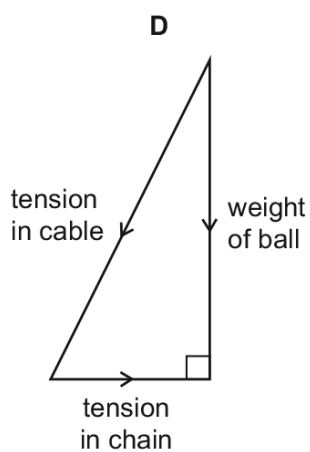
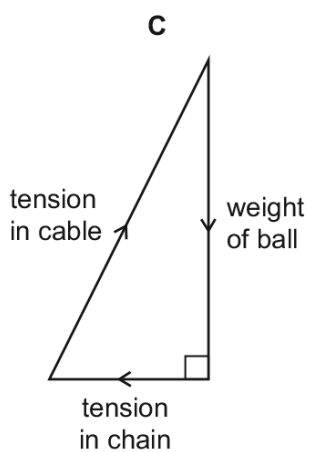
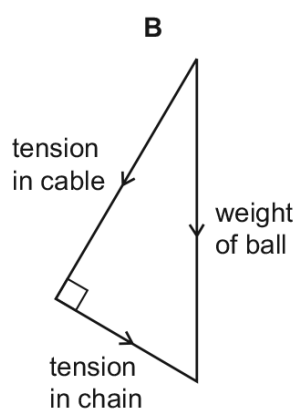
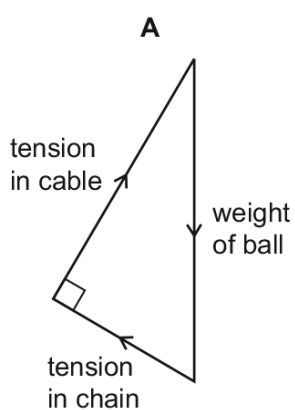
A**B****C****D**

425. 9702_w19_qp_13 Q: 12

A heavy ball hanging from a cable is held in equilibrium by a chain, as shown.



Which vector diagram shows the three forces acting on the ball?



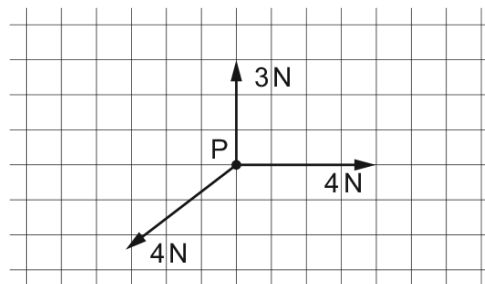
426. 9702_m18_qp_12 Q: 13

In which example is it **not** possible for the underlined body to be in equilibrium?

- A An aeroplane climbs at a steady rate.
 - B An aeroplane tows a glider at a constant altitude.
 - C A speedboat changes direction at a constant speed.
 - D Two boats tow a ship into harbour.
-

427. 9702_s18_qp_12 Q: 15

The vector diagram shows three coplanar forces acting on an object at P.



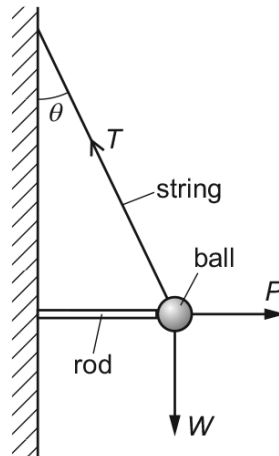
The magnitude of the resultant of these three forces is 1 N.

What is the direction of this resultant force?

- A B C D
-

428. 9702_s18_qp_12 Q: 17

The diagram shows a ball of weight W hanging in equilibrium from a string.



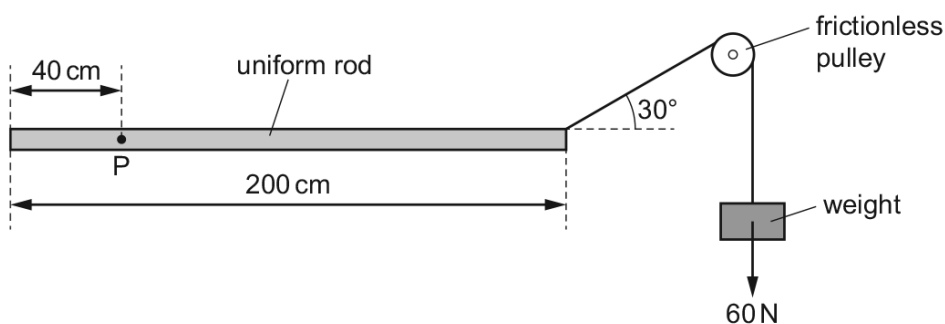
The string is at an angle θ to the vertical. The tension in the string is T . The ball is held away from the wall by a horizontal force P from a metal rod.

What is the relationship between the magnitudes of T , P and W ?

- A $P = T \cos \theta$ and $W = T \sin \theta$
- B $T = P + W$
- C $T^2 = P^2 + W^2$
- D $W = P \tan \theta$ and $W = T \cos \theta$

429. 9702_w18_qp_11 Q: 11

A uniform rod of length 200 cm is freely pivoted at point P. The rod is held horizontally in equilibrium by a 60 N weight that is attached to the rod by a string passing over a frictionless pulley.

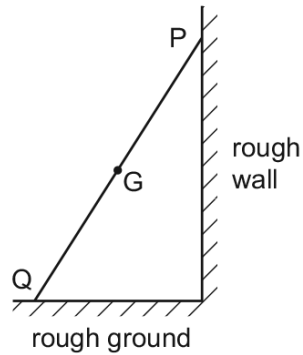


What is the weight of the rod?

- A 30 N
- B 60 N
- C 80 N
- D 140 N

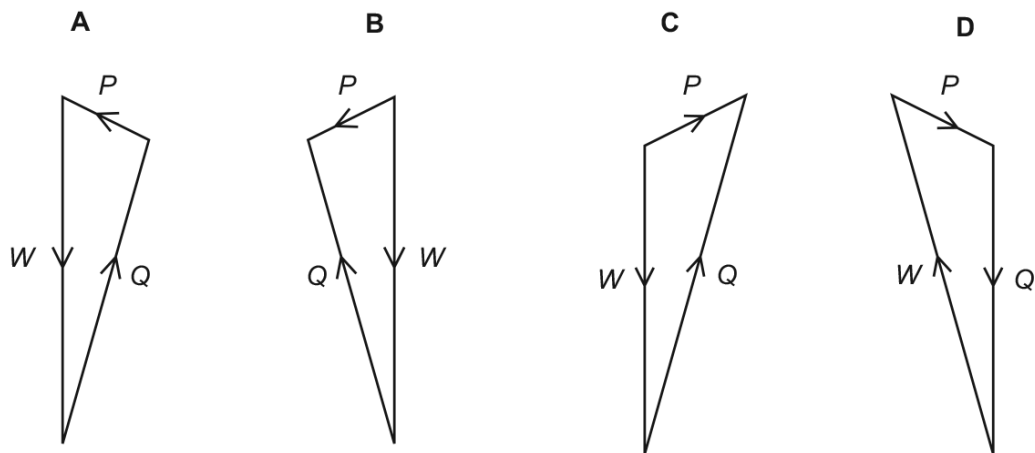
430. 9702_w18_qp_11 Q: 12

A ladder rests in equilibrium on rough ground against a rough wall.



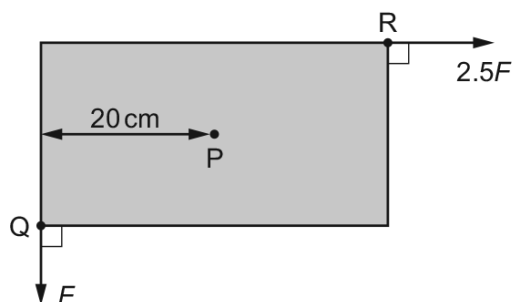
The weight W of the ladder acts through the centre of gravity G . Forces also act on the ladder at P and at Q . These forces are P and Q respectively.

Which vector triangle represents the forces on the ladder?



431. 9702_w18_qp_12 Q: 12

A uniform rectangular board is supported by a frictionless pivot at its centre point P.



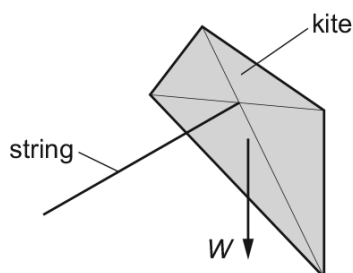
Two forces act in the plane of the board. Force F acts at corner Q and force $2.5F$ acts at corner R. The perpendicular distance between the line of action of force F and point P is 20 cm. The board is in equilibrium.

What is the area of the board?

- A** 160 cm^2 **B** 320 cm^2 **C** 640 cm^2 **D** 1600 cm^2

432. 9702_w18_qp_12 Q: 13

A kite is in equilibrium at the end of a string, as shown.



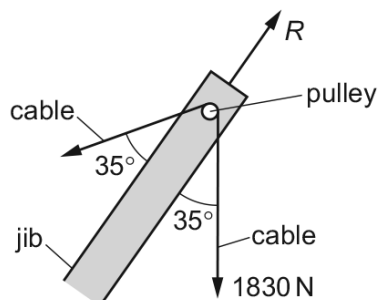
The kite has three forces acting on it: the weight W , the tension T in the string, and the force F from the wind.

Which vector diagram represents the forces acting on the kite?



433. 9702_w18_qp_13 Q: 13

The diagram shows the jib of a crane at an angle of 35° to the vertical. A cable passes over a frictionless pulley and carries a load of 1830 N.



The force R that the pulley exerts on the cable is in line with the jib. The cable and the pulley are in equilibrium.

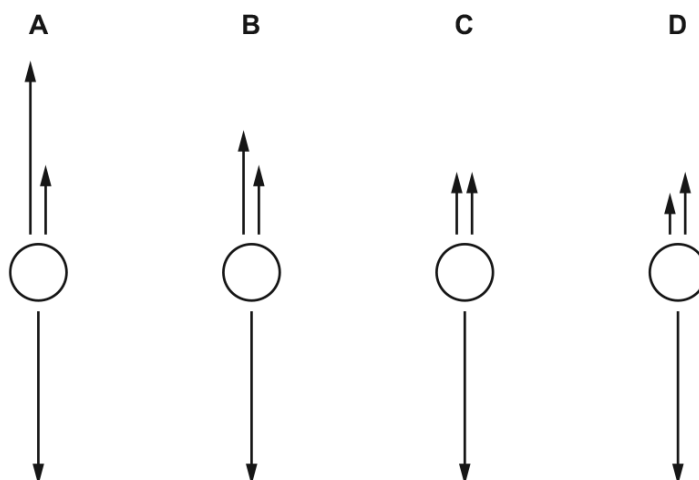
What is the value of R ?

- A** 1000 N **B** 1500 N **C** 2100 N **D** 3000 N

434. 9702_m17_qp_12 Q: 11

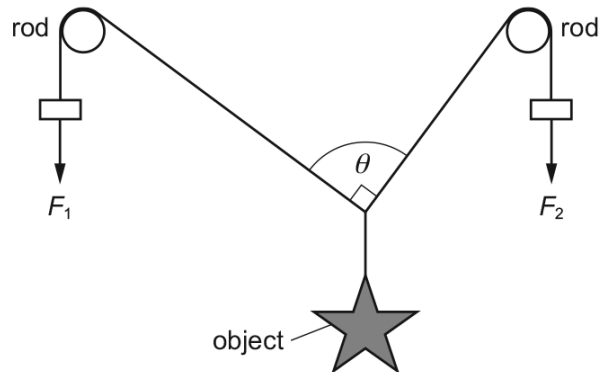
A spherical object falls through water at constant speed. Three forces act on the object.

Which diagram, showing these three forces to scale, is correct?



435. 9702_m17_qp_12 Q: 14

An object hangs by means of two cords around two rods, as shown.



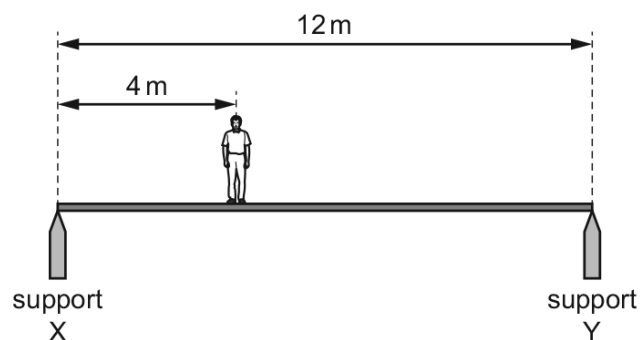
The object is held in equilibrium by the forces F_1 and F_2 . The object weighs 10 N. There is negligible friction between the rods and cords. Angle θ is 90° .

Which row of the table gives an angle θ of 90° ?

	F_1/N	F_2/N
A	4.0	6.0
B	6.0	4.0
C	6.0	8.0
D	8.0	6.0

436. 9702_s17_qp_11 Q: 13

A uniform horizontal footbridge is 12 m long and weighs 4000 N. It rests on two supports X and Y as shown.



A man of weight 600 N is a distance of 4 m from support X.

What is the upward force on the footbridge from support X?

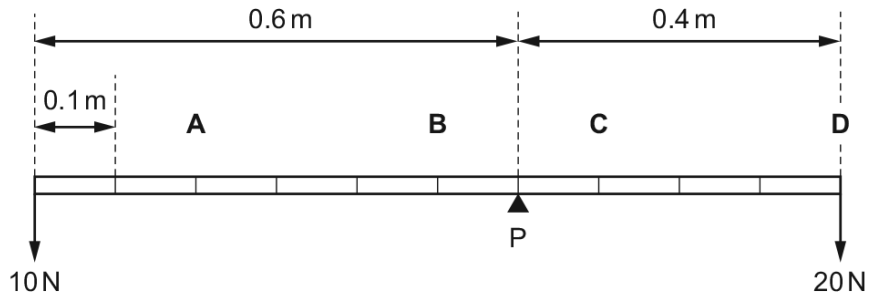
- A** 2200 N **B** 2300 N **C** 2400 N **D** 2600 N

437. 9702_s17_qp_12 Q: 12

A uniform beam is pivoted at P as shown. Weights of 10 N and 20 N are attached to its ends.

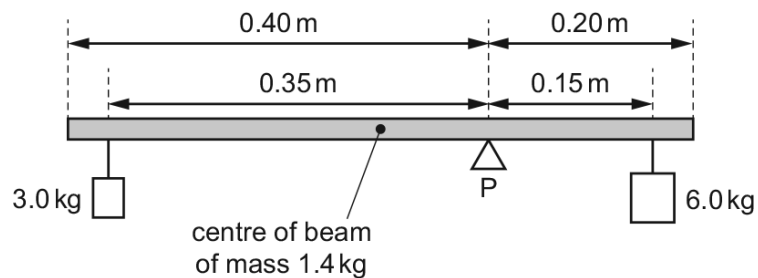
The length of the beam is marked at 0.1 m intervals. The weight of the beam is 100 N.

At which point should a further weight of 20 N be attached to achieve equilibrium?



438. 9702_s17_qp_13 Q: 11

A uniform beam of mass 1.4 kg is pivoted at P as shown. The beam has a length of 0.60 m and P is 0.20 m from one end. Loads of 3.0 kg and 6.0 kg are suspended 0.35 m and 0.15 m from the pivot as shown.

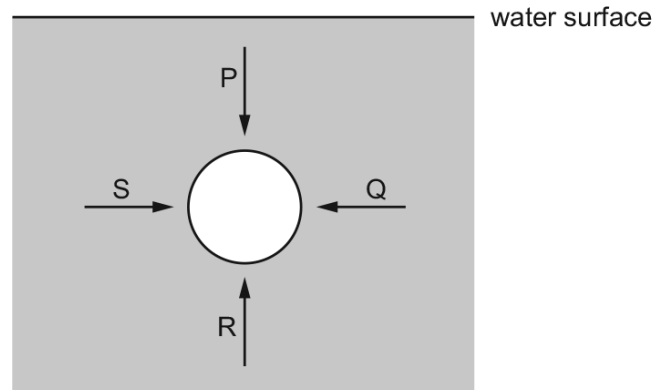


What is the torque that must be applied to the beam in order to maintain it in equilibrium?

- A** 0.010 Nm **B** 0.10 Nm **C** 0.29 Nm **D** 2.8 Nm

439. 9702_s17_qp_13 Q: 13

The diagram represents a sphere under water. P, Q, R and S are forces acting on the sphere due to the pressure of the water.



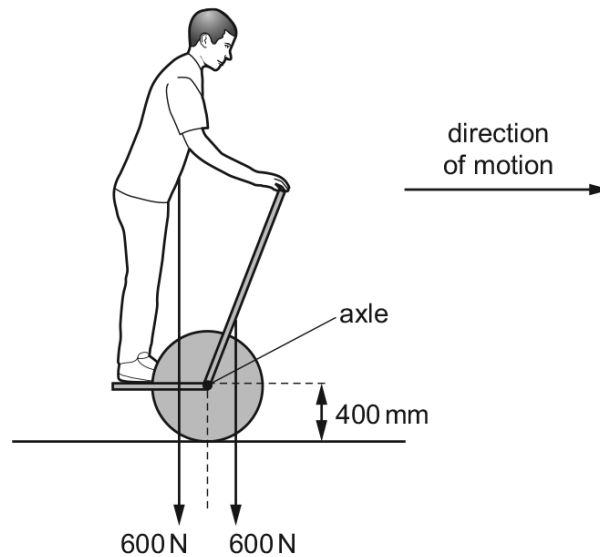
Each force acts perpendicularly to the sphere's surface. P and R act in opposite directions vertically. Q and S act in opposite directions horizontally.

Which information about the magnitudes of the forces is correct?

- A** $P < R$ and $S = Q$
 - B** $P > R$ and $S = Q$
 - C** $P = R$ and $S = Q$ and $P < S$
 - D** $P = R$ and $S = Q$ and $P = S$
-

440. 9702_w17_qp_11 Q: 14

The diagram shows a motorised vehicle for carrying one person.



The vehicle has two wheels on one axle. The passenger stands on a platform between the wheels.

The weight of the machine is 600 N. Its centre of mass is 200 mm in front of the axle. The wheel radius is 400 mm.

When stationary, a passenger of weight 600 N stands with his centre of mass 200 mm behind the axle to balance the machine.

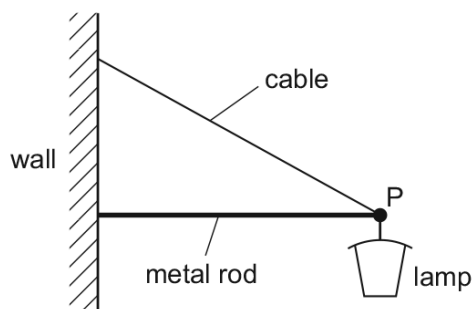
The motor is now switched on to provide a horizontal force of 90 N at the ground to move the vehicle forwards.

How far and in which direction must the passenger move his centre of mass to maintain balance?

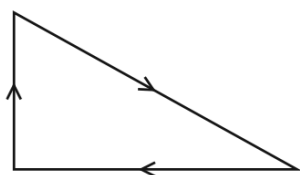
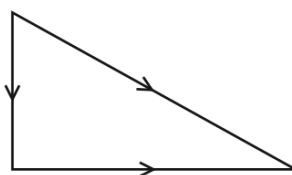
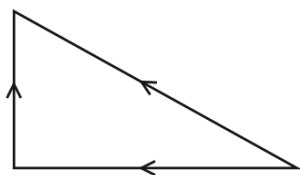
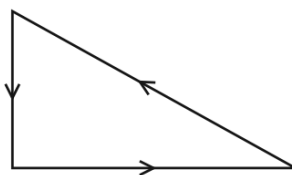
- A 60 mm backwards
- B 60 mm forwards
- C 140 mm backwards
- D 140 mm forwards

441. 9702_w17_qp_12 Q: 13

A street lamp is fixed to a wall by a metal rod and a cable.

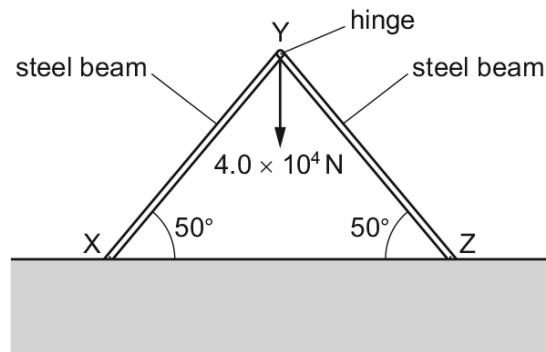


Which vector triangle could represent the forces acting at point P?

A**B****C****D**

442. 9702_w17_qp_12 Q: 14

Two rigid steel beams XY and YZ are fixed at their lower ends and are hinged at Y. Each beam is inclined at 50° to the horizontal, as shown. A weight of $4.0 \times 10^4 \text{ N}$ hangs from Y. The structure is in equilibrium.

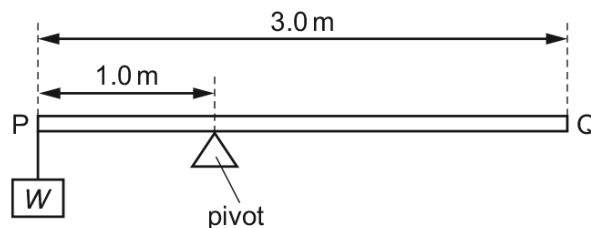


What is the force exerted by each beam on the hinge at Y?

- A** $2.6 \times 10^4 \text{ N}$ **B** $3.1 \times 10^4 \text{ N}$ **C** $5.2 \times 10^4 \text{ N}$ **D** $6.2 \times 10^4 \text{ N}$

443. 9702_m16_qp_12 Q: 12

The diagram shows a uniform beam PQ. The length of the beam is 3.0 m and its weight is 50 N. The beam is supported on a pivot 1.0 m from end P. A load of weight W is hung from end P and the beam is in equilibrium.

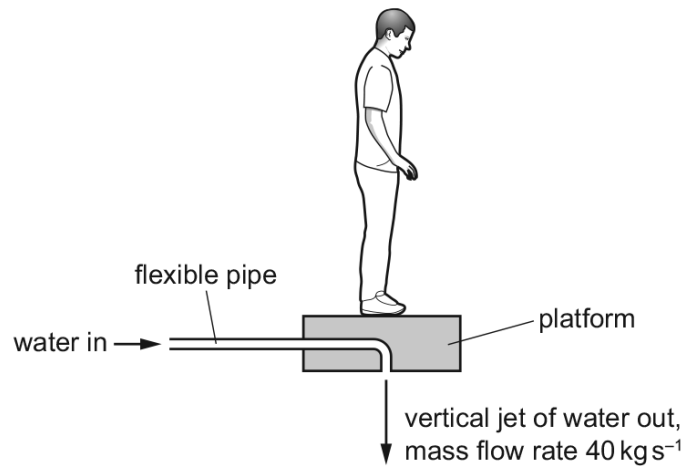


What is the value of W ?

- A** 25 N **B** 50 N **C** 75 N **D** 100 N

444. 9702_s16_qp_11 Q: 11

The diagram shows a man standing on a platform that is attached to a flexible pipe. Water is pumped through the pipe so that the man and platform remain at a constant height.



The resultant vertical force on the platform is zero. The combined mass of the man and platform is 96 kg. The mass of water that is discharged vertically downwards from the platform each second is 40 kg.

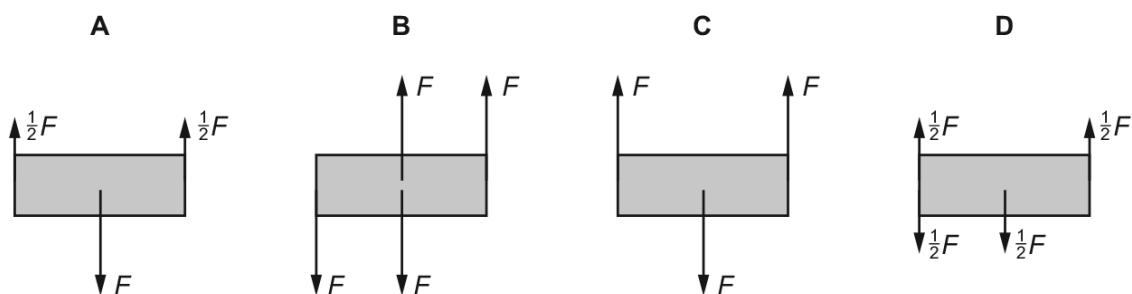
What is the speed of the water leaving the platform?

- A** 2.4 ms^{-1} **B** 6.9 ms^{-1} **C** 24 ms^{-1} **D** 47 ms^{-1}

445. 9702_s16_qp_11 Q: 12

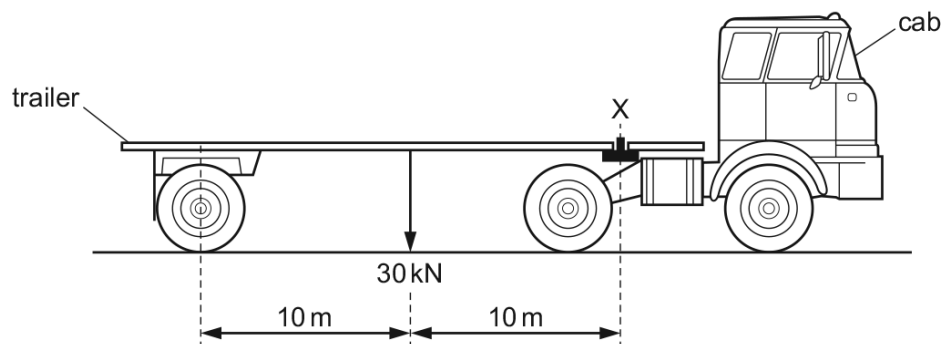
Forces are applied to a rigid body. The forces all act in the same plane.

In which diagram is the body in equilibrium?



446. 9702_s16_qp_11 Q: 14

A trailer of weight 30 kN is attached to a cab at X, as shown in the diagram.

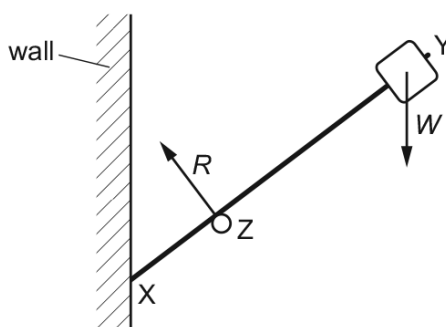


What is the upward force exerted at X by the cab on the trailer?

- A** 3 kN **B** 15 kN **C** 30 kN **D** 60 kN

447. 9702_s16_qp_12 Q: 12

A light rigid rod XY has an object of weight W fixed at one end. The rod is in equilibrium, resting on a roller at Z and a vertical wall at X. The roller exerts a force R on the rod as shown. The diagram shows the directions, but not the magnitudes, of the forces R and W .



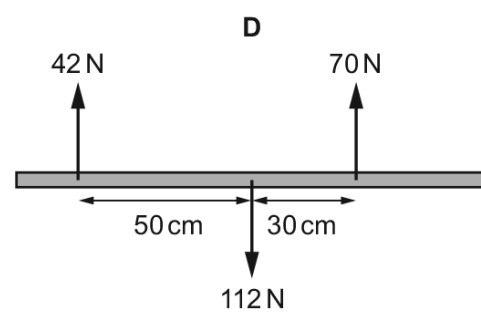
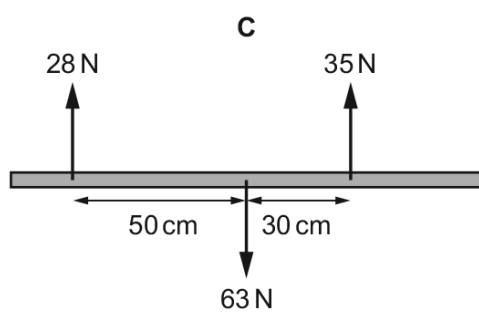
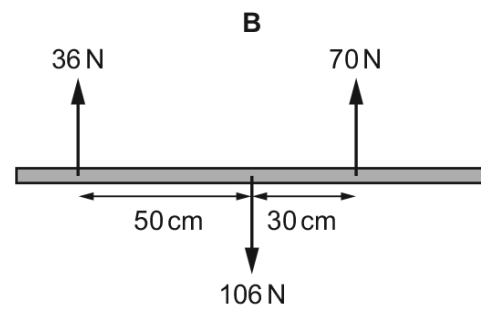
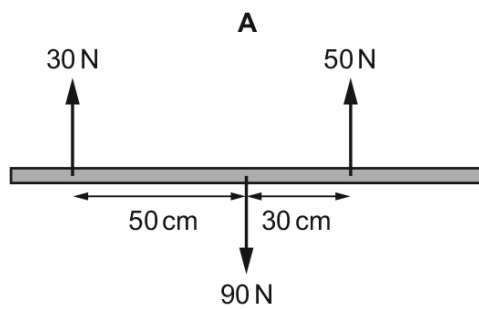
What is the direction of the force on the rod at X?

- A**  **B**  **C**  **D** 

448. 9702_w16_qp_11 Q: 15

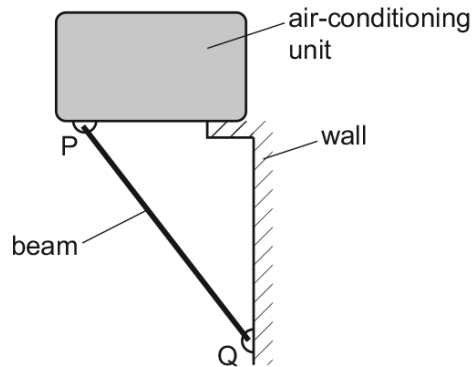
Four beams of the same length each have three forces acting on them.

Which beam has both zero resultant force and zero resultant torque acting?

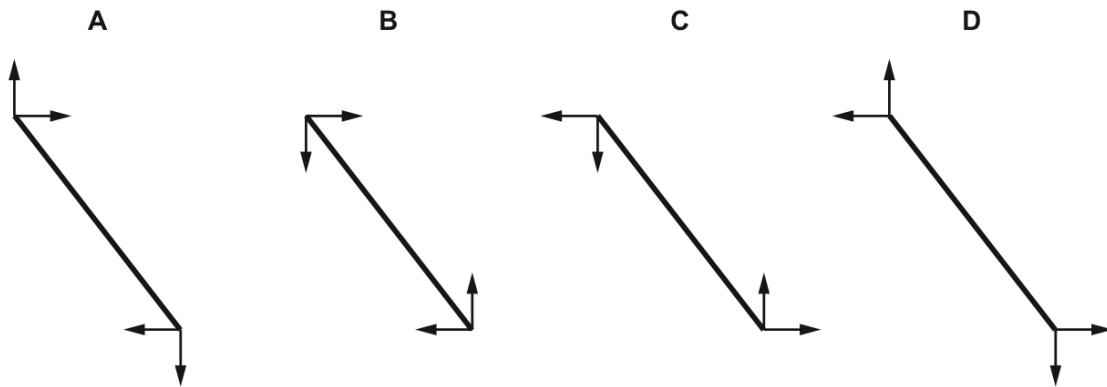


449. 9702_w16_qp_11 Q: 16

An air-conditioning unit is supported by a rigid beam PQ, as shown.



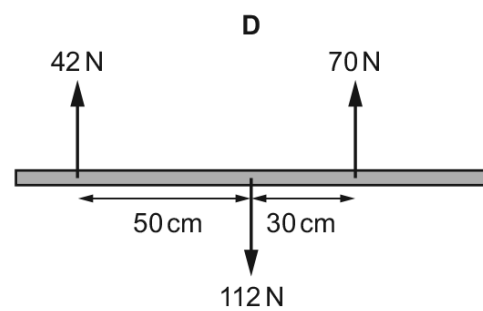
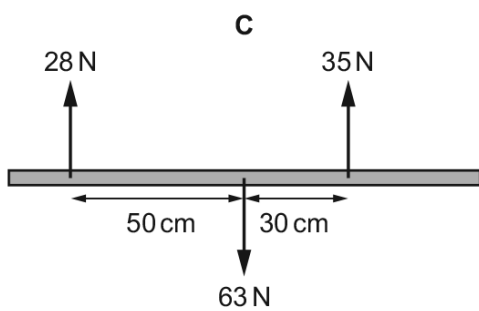
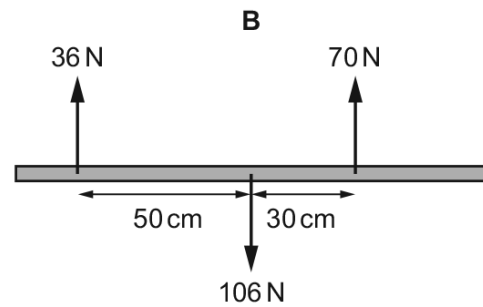
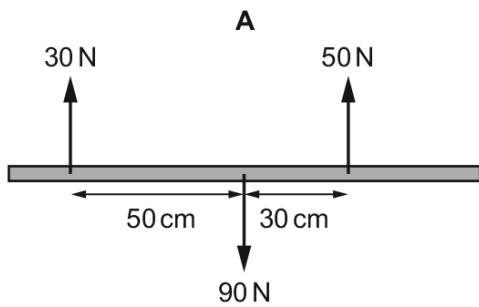
Which diagram shows the directions of the horizontal and vertical forces acting on the ends of the beam?



450. 9702_w16_qp_13 Q: 15

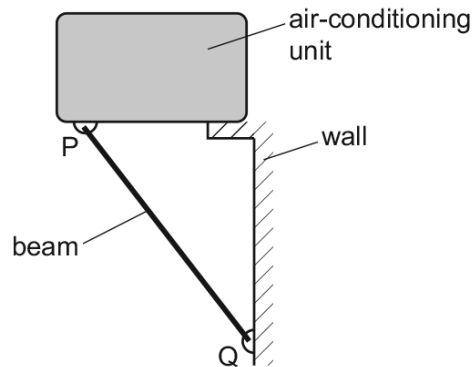
Four beams of the same length each have three forces acting on them.

Which beam has both zero resultant force and zero resultant torque acting?

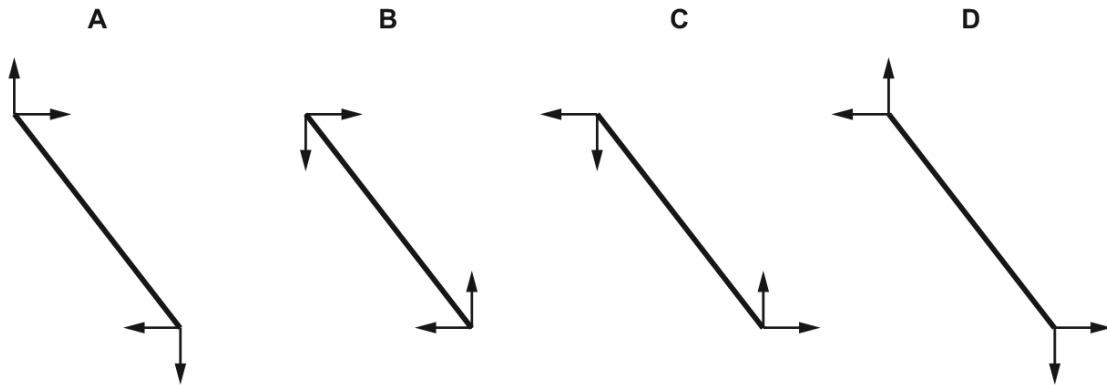


451. 9702_w16_qp_13 Q: 16

An air-conditioning unit is supported by a rigid beam PQ, as shown.

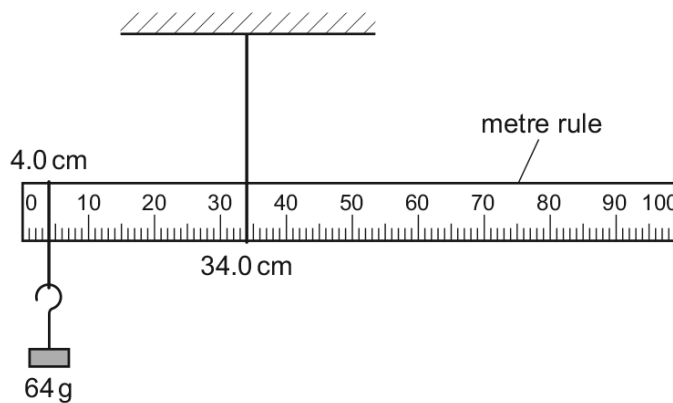


Which diagram shows the directions of the horizontal and vertical forces acting on the ends of the beam?



452. 9702_s15_qp_11 Q: 15

A uniform metre rule is pivoted at the 34.0 cm mark, as shown.



The rule balances when a 64 g mass is hung from the 4.0 cm mark.

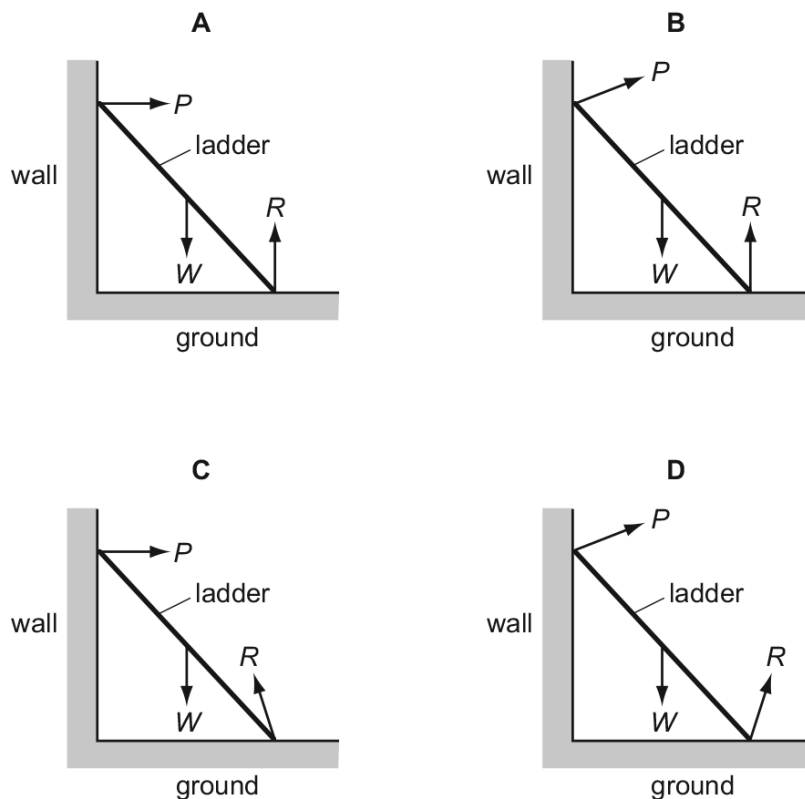
What is the mass of the metre rule?

- A** 38 g **B** 44 g **C** 120 g **D** 136 g
-

453. 9702_s15_qp_12 Q: 14

A ladder is positioned on icy (frictionless) ground and is leant against a rough wall. At the instant of release it begins to slide.

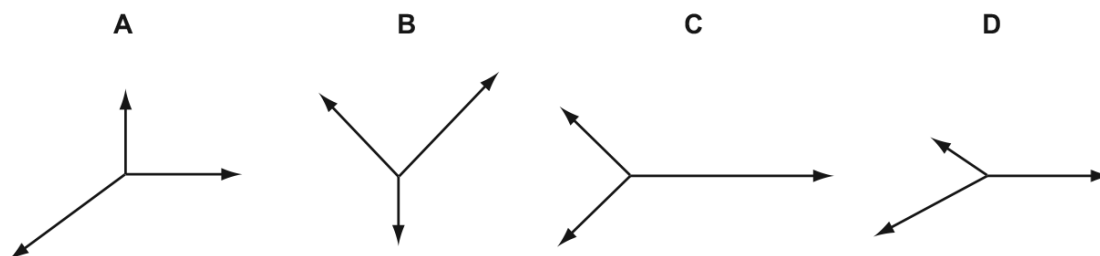
Which diagram correctly shows the directions of the forces P , W and R acting on the ladder as it slides?



454. 9702_s15_qp_13 Q: 16

The diagrams represent systems of coplanar forces acting at a point. The lengths of the force vectors represent the magnitudes of the forces.

Which system of forces is in equilibrium?



5.4 Density and pressure

455. 9702_s20_qp_11 Q: 15

A rectangular metal bar exerts a pressure of $15\,200\text{ Pa}$ on the horizontal surface on which it rests.

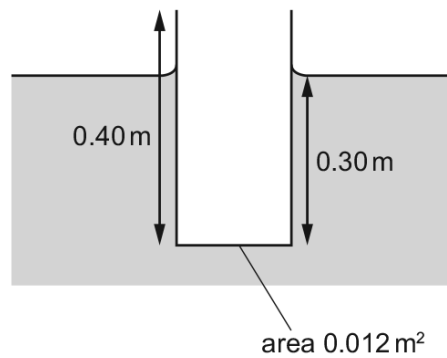
The height of the metal bar is 80 cm .

What is the density of the metal?

- A 190 kg m^{-3}
- B 1900 kg m^{-3}
- C $19\,000\text{ kg m}^{-3}$
- D $190\,000\text{ kg m}^{-3}$

456. 9702_s20_qp_12 Q: 13

A pipe, open at one end, floats in a liquid as shown.



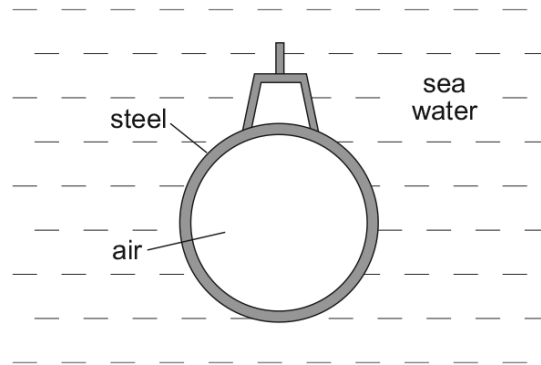
The cross-sectional area of the pipe is 0.012 m^2 . The weight of the pipe is 32 N .

What is the density of the liquid?

- A 680 kg m^{-3}
- B 910 kg m^{-3}
- C 6700 kg m^{-3}
- D 8900 kg m^{-3}

457. 9702_s20_qp_13 Q: 11

A submarine is in equilibrium in a fully submerged position.



What causes the upthrust on the submarine?

- A** The air in the submarine is less dense than sea water.
- B** There is a difference in water pressure acting on the top and on the bottom of the submarine.
- C** The sea water exerts a greater upward force on the submarine than the weight of the steel.
- D** The submarine displaces its own volume of sea water.

458. 9702_s20_qp_13 Q: 15

Liquid Q has twice the density of liquid R.

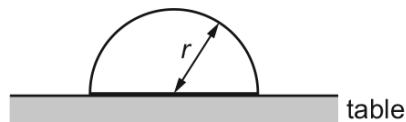
At depth x in liquid R, the pressure due to the liquid is 4 kPa.

At which depth in liquid Q is the pressure due to the liquid 7 kPa?

- A** $\frac{2x}{7}$
- B** $\frac{7x}{8}$
- C** $\frac{8x}{7}$
- D** $\frac{7x}{2}$

459. 9702_m19_qp_12 Q: 14

An object shaped as a hemisphere rests with its flat surface on a table. The object has radius r and density ρ .



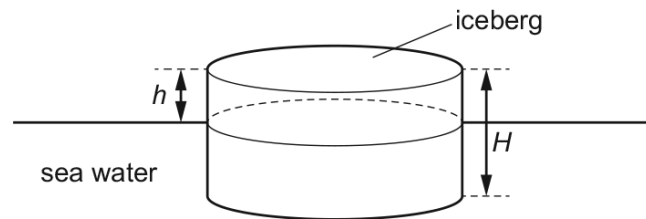
The volume of a sphere is $\frac{4}{3}\pi r^3$.

Which average pressure does the object exert on the table?

- A** $\frac{1}{3}\rho r^2$
- B** $\frac{1}{3}\rho r^2 g$
- C** $\frac{2}{3}\rho r$
- D** $\frac{2}{3}\rho r g$

460. 9702_s19_qp_11 Q: 12

A cylindrical iceberg of height H floats in sea water. The top of the iceberg is at height h above the surface of the water.



The density of ice is ρ_i and the density of sea water is ρ_w .

What is the height h of the iceberg above the sea water?

- A** $\left(1 - \frac{\rho_i}{\rho_w}\right)H$ **B** $\left(\frac{\rho_i}{\rho_w} - 1\right)H$ **C** $\frac{\rho_w}{\rho_i}H$ **D** $\frac{\rho_i}{\rho_w}H$

461. 9702_s19_qp_11 Q: 16

An empty glass beaker has a mass of 103 g. When filled with water, it has a total mass of 361 g. When filled with cooking oil, it has a total mass of 351 g.

The density of water is 1.00 g cm^{-3} .

What is the density of the cooking oil?

- A** 0.961 g cm^{-3} **B** 0.972 g cm^{-3} **C** 1.03 g cm^{-3} **D** 1.04 g cm^{-3}

462. 9702_s19_qp_12 Q: 15

A volume of 1.5 m^3 of water is mixed with 0.50 m^3 of alcohol. The density of water is 1000 kg m^{-3} and the density of alcohol is 800 kg m^{-3} .

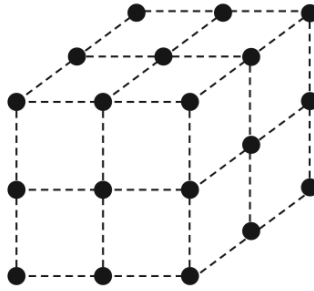
The volume of the mixture is 2.0 m^3 .

What is the density of the mixture?

- A** 850 kg m^{-3} **B** 900 kg m^{-3} **C** 940 kg m^{-3} **D** 950 kg m^{-3}

463. 9702_s19_qp_12 Q: 21

The diagram shows the arrangement of atoms in a particular crystal.



Each atom is at the corner of a cube.

The mass of each atom is 3.5×10^{-25} kg. The density of the crystal is 9.2×10^3 kg m⁻³.

What is the shortest distance between the centres of two adjacent atoms?

- A 3.8×10^{-29} m
- B 6.2×10^{-15} m
- C 3.4×10^{-10} m
- D 3.0×10^{-9} m

464. 9702_s19_qp_13 Q: 14

Water has a density of 1.0 g cm^{-3} .

Glycerine has a density of 1.3 g cm^{-3} .

A student measures out a volume of 40 cm^3 of glycerine into a container.

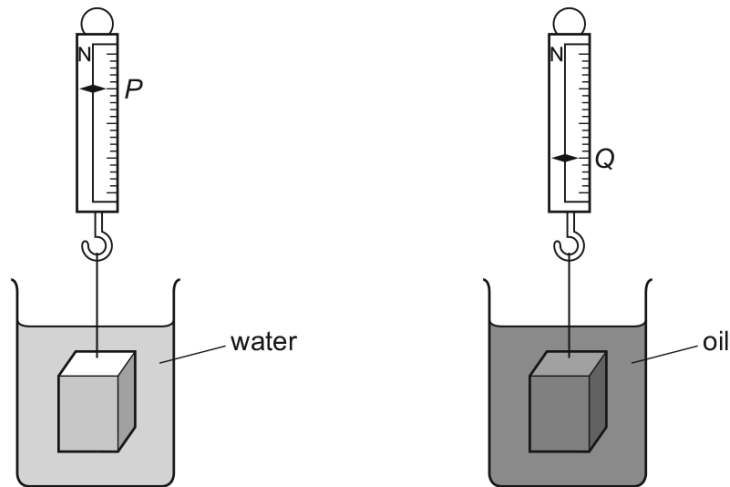
The student adds water to the container to make a mixture of water and glycerine. Assume that the total volume of water and glycerine does not change when the two liquids are mixed.

Which volume of water needs to be added to make a mixture of density 1.1 g cm^{-3} ?

- A 4.0 cm^3
- B 8.0 cm^3
- C 34 cm^3
- D 80 cm^3

465. 9702_w19_qp_11 Q: 11

An object of weight W is suspended from a newton meter. When the object is completely immersed in water, the newton meter reads P . When the object is completely immersed in oil, the newton meter reads Q .



What is the ratio $\frac{\text{density of oil}}{\text{density of water}}$?

- A $\frac{W-P}{Q-P}$ B $\frac{Q-P}{W-P}$ C $\frac{W-P}{W-Q}$ D $\frac{W-Q}{W-P}$

466. 9702_w19_qp_11 Q: 14

In a large container in an oil refinery, three oils of different densities are mixed. No chemical activity occurs.

The mixture consists of:

1200 kg of oil of density 1100 kg m^{-3}

1500 kg of oil of density 860 kg m^{-3}

4000 kg of oil of density 910 kg m^{-3} .

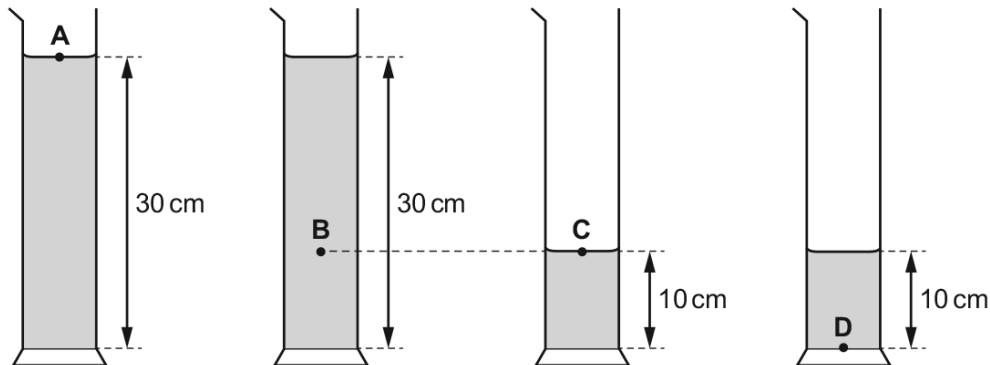
What is the density of the mixture?

- A 927 kg m^{-3} B 933 kg m^{-3} C 957 kg m^{-3} D 1045 kg m^{-3}

467. 9702_w19_qp_12 Q: 13

Four measuring cylinders are filled with the same liquid to the heights shown.

At which position is the pressure the greatest?



468. 9702_w19_qp_13 Q: 10

A solid sphere, which is less dense than water, is held completely immersed in water a few metres below the surface. The density of the water is uniform.

The sphere is released. Immediately after release, the sphere rises.

Which row correctly describes the changes in the upthrust on the sphere and the resultant force on the sphere?

	upthrust on the sphere	resultant force on the sphere
A	constant	increasing
B	constant	decreasing
C	decreasing	increasing
D	decreasing	decreasing

469. 9702_w19_qp_13 Q: 13

At sea level, atmospheric pressure is 100 kPa and the density of air is 1.3 kg m^{-3} .

Assume that the density of air decreases linearly with height above sea level.

What is an estimate of the total height of the atmosphere based on this information?

A 7.8 km **B** 16 km **C** 77 km **D** 150 km

470. 9702_m18_qp_12 Q: 4

The density of paper is 800 kg m^{-3} . A typical sheet of paper has a width of 210 mm and a length of 300 mm.

The thickness of a pack of 500 sheets of paper is 50 mm.

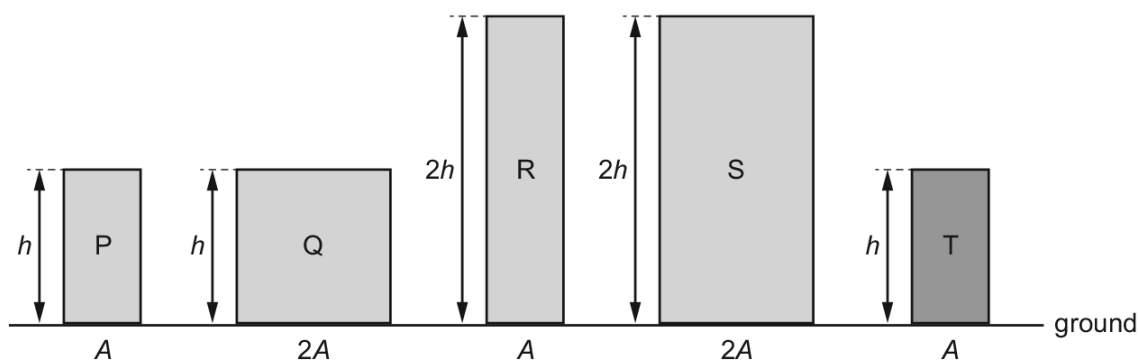
What is the mass of a single sheet of paper?

- A** 0.5 g **B** 5 g **C** 50 g **D** 500 g

471. 9702_s18_qp_11 Q: 11

Blocks P, Q, R and S are made from material of the same density. Block T is made from a material of twice the density of the material of the other blocks.

The cross-sectional area and height of each of the blocks are shown.



Which two blocks exert the same pressure on the ground?

- A** P and T **B** Q and R **C** Q and S **D** S and T

472. 9702_s18_qp_11 Q: 13

Liquids X and Y are stored in large open tanks. Liquid X has a density of 800 kg m^{-3} and liquid Y has a density of 1200 kg m^{-3} .

At which depths are the pressures equal?

	depth in liquid X/m	depth in liquid Y/m
A	8	20
B	10	15
C	15	10
D	20	8

473. 9702_s18_qp_12 Q: 10

The density of water is 1.0 g cm^{-3} and the density of glycerine is 1.3 g cm^{-3} .

Water is added to a measuring cylinder containing 40 cm^3 of glycerine so that the density of the mixture is 1.1 g cm^{-3} . Assume that the mixing process does not change the total volume of the liquid.

What is the volume of water added?

- A** 40 cm^3 **B** 44 cm^3 **C** 52 cm^3 **D** 80 cm^3
-

474. 9702_s18_qp_12 Q: 12

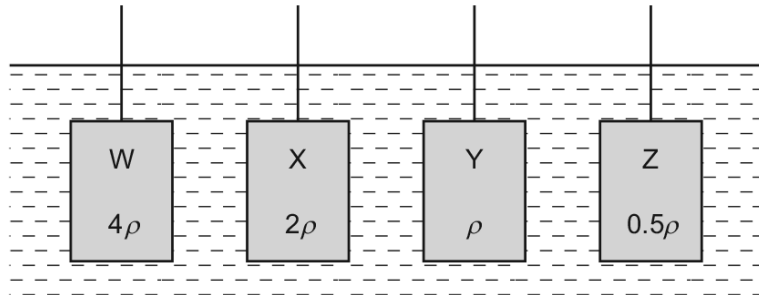
A cylindrical block of wood has cross-sectional area A and weight W . It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively.

Which expression is equal to the upthrust on the block?

- A** $(p_b - p_t)$
B $(p_b - p_t)A$
C $(p_b - p_t)A - W$
D $(p_b - p_t)A + W$
-

475. 9702_s18_qp_13 Q: 10

Four cuboids with identical lengths, breadths and heights are immersed in water. The cuboids are held at the same depth and in identical orientations by vertical rods, as shown.



Water has density ρ .

Cuboid W is made of material of density 4ρ .

Cuboid X is made of material of density 2ρ .

Cuboid Y is made of material of density ρ .

Cuboid Z is made of material of density 0.5ρ .

Which statement is correct?

- A** The upthrust of the water on each of the cuboids is the same.
- B** The upthrust of the water on W is twice the upthrust of the water on X.
- C** The upthrust of the water on X is twice the upthrust of the water on W.
- D** The upthrust of the water on Y is zero.

476. 9702_s18_qp_13 Q: 11

A rectangular block of lead of density $1.13 \times 10^4 \text{ kg m}^{-3}$ has sides of length 12.0 cm, 15.0 cm and 10.0 cm.

What is the maximum pressure the block can exert when resting on a table?

- A** 1.13 kPa **B** 1.70 kPa **C** 11.1 kPa **D** 16.6 kPa

477. 9702_s18_qp_13 Q: 13

Full-fat milk is made up of fat-free milk mixed with fat.

A volume of $1.000 \times 10^{-3} \text{ m}^3$ of full-fat milk has a mass of 1.035 kg. It contains 4.00% fat by volume.

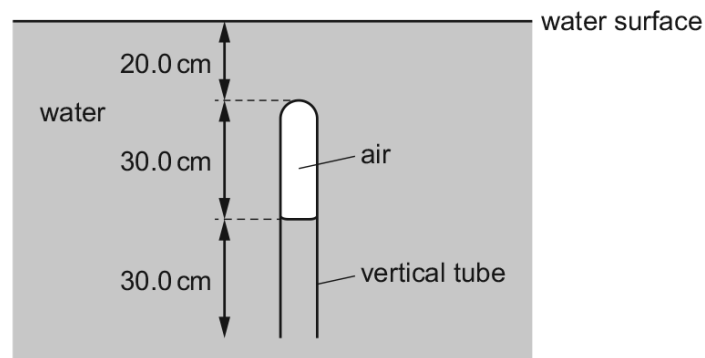
The density of fat-free milk is $1.040 \times 10^3 \text{ kg m}^{-3}$.

What is the density of fat?

- A $1.25 \times 10^2 \text{ kg m}^{-3}$
 - B $9.15 \times 10^2 \text{ kg m}^{-3}$
 - C $9.28 \times 10^2 \text{ kg m}^{-3}$
 - D $1.16 \times 10^3 \text{ kg m}^{-3}$
-

478. 9702_w18_qp_11 Q: 13

A vertical tube, closed at one end, is immersed in water. A column of air is trapped inside the tube.



The density of water is 1000 kg m^{-3} .

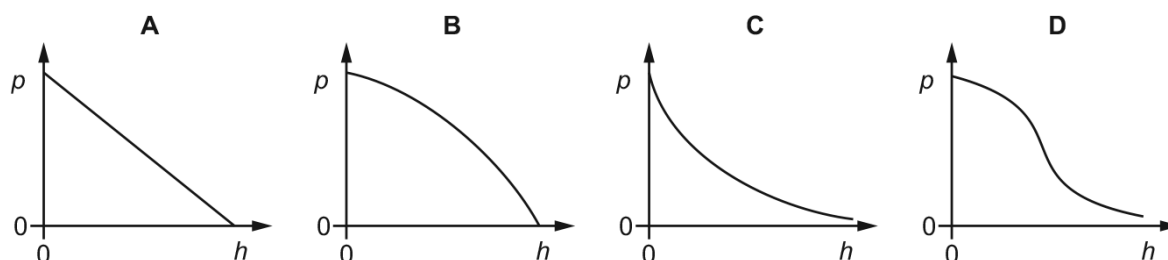
What is the difference between the pressure of the air in the tube and the atmospheric pressure?

- A 1960 Pa
 - B 2940 Pa
 - C 4910 Pa
 - D 7850 Pa
-

479. 9702_w18_qp_12 Q: 14

The density of the air in the atmosphere decreases as the height h above the surface of the Earth increases.

Which graph best shows the variation with height h of the pressure p of the air?



480. 9702_w18_qp_13 Q: 14

What is a unit for density?

- A** Nm^{-3} **B** g mm^{-1} **C** kg cm^{-2} **D** $\mu\text{g mm}^{-3}$

481. 9702_s17_qp_11 Q: 14

A metal block has a mass of 750 g. 60% of the mass is magnesium and the remainder is copper.

The density of magnesium is 1.7 g cm^{-3} .

The density of copper is 9.0 g cm^{-3} .

What is the density of the block?

- A** 2.5 g cm^{-3} **B** 4.6 g cm^{-3} **C** 5.4 g cm^{-3} **D** 10.7 g cm^{-3}

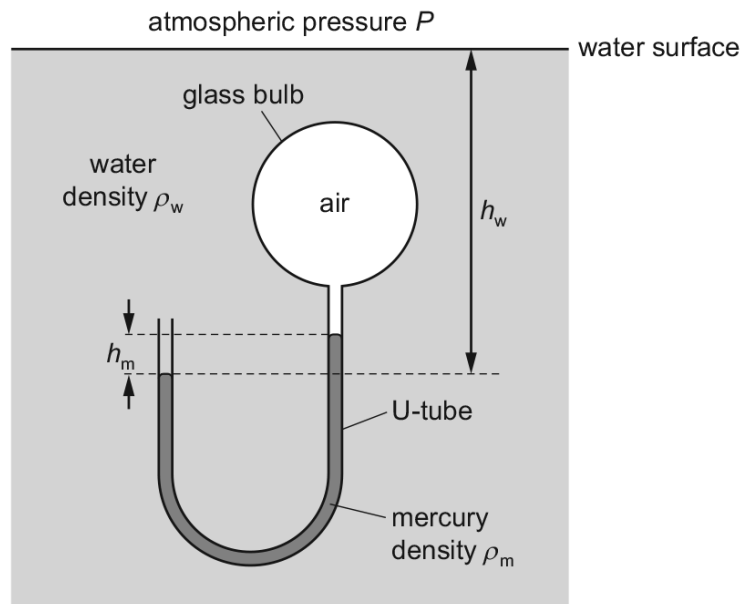
482. 9702_s17_qp_12 Q: 13

What are the SI base units of the quantity $\frac{\text{pressure}}{\text{density}}$?

- A** s^{-2} **B** $\text{kg}^2 \text{s}^{-2}$ **C** $\text{kg}^2 \text{m}^2 \text{s}^{-2}$ **D** $\text{m}^2 \text{s}^{-2}$

483. 9702_w17_qp_12 Q: 15

Air is trapped inside a glass bulb which is immersed in water and attached to a U-tube containing mercury. The densities of water and mercury are ρ_w and ρ_m respectively. The surface of the water is open to the atmosphere where atmospheric pressure is P .



The acceleration of free fall is g .

What is the pressure of the air in the glass bulb?

- A $P + g\rho_w h_w + g\rho_m h_m$
- B $P + g\rho_w h_w - g\rho_m h_m$
- C $g\rho_w h_w + g\rho_m h_m$
- D $g\rho_w h_w - g\rho_m h_m$

484. 9702_w17_qp_13 Q: 14

A thin horizontal plate of area 0.036 m^2 is beneath the surface of a liquid of density 930 kg m^{-3} . The force on one side of the plate due to the pressure of the liquid is 290 N .

What is the depth of the plate beneath the surface of the liquid?

- A 0.88 m
- B 1.1 m
- C 1.8 m
- D 8.7 m

485. 9702_m16_qp_12 Q: 14

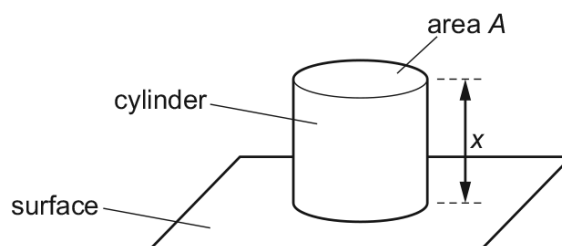
A giant squid of length 20.0 m is vertical in seawater, with the top of the squid at a depth of 8.00 m. The density of seawater is 1050 kg m^{-3} .

What is the difference in pressure between the top and the bottom of the squid?

- A** 82 000 Pa **B** 206 000 Pa **C** 288 000 Pa **D** 389 000 Pa

486. 9702_s16_qp_11 Q: 13

A solid metal cylinder stands on a horizontal surface, as shown.



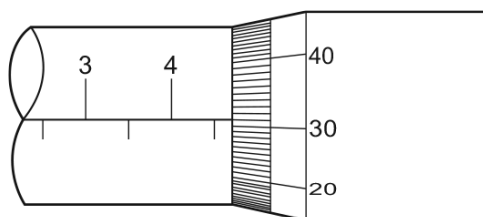
The cylinder has length x and cross-sectional area A . The cylinder exerts a pressure p on the surface. The acceleration of free fall is g .

Which expression gives the density of the metal of the cylinder?

- A** $\frac{gx}{p}$ **B** $\frac{p}{gx}$ **C** $\frac{gx}{pA}$ **D** $\frac{pA}{gx}$

487. 9702_s16_qp_11 Q: 15

The diameter of a solid metal sphere is measured using a micrometer screw gauge. The diagram shows an enlargement of the shaft of the micrometer screw gauge when taking the measurement.



The mass of the sphere is 0.450 g.

What is the density of the metal used to make the sphere?

- A** 965 kg m^{-3} **B** 1340 kg m^{-3} **C** 7720 kg m^{-3} **D** 10700 kg m^{-3}

488. 9702_s16_qp_12 Q: 13

In a large container in an oil refinery, three oils of different densities are mixed. No chemical activity occurs.

The mixture consists of

1200 kg of oil of density 1100 kg m^{-3} ,

1500 kg of oil of density 860 kg m^{-3} ,

4000 kg of oil of density 910 kg m^{-3} .

What is the density of the mixture?

- A** 927 kg m^{-3} **B** 957 kg m^{-3} **C** 1010 kg m^{-3} **D** 1080 kg m^{-3}
-

489. 9702_s16_qp_12 Q: 15

The density of air on the Earth decreases almost linearly with height from 1.22 kg m^{-3} at sea level to 0.74 kg m^{-3} at an altitude of 5000 m.

Atmospheric pressure at the Earth's surface on a particular day is 100 000 Pa. The value of g between the Earth's surface and an altitude of 5000 m can be considered to have a constant value of 9.7 m s^{-2} .

What will be the atmospheric pressure at an altitude of 5000 m?

- A** 36 000 Pa **B** 48 000 Pa **C** 52 000 Pa **D** 59 000 Pa
-

490. 9702_s16_qp_13 Q: 11

The IKAROS satellite has mass 320 kg and moves through space using a solar sail of area 20 m^2 . The average solar wind pressure is $1.0 \times 10^{-5} \text{ N m}^{-2}$.

What is the acceleration of the satellite caused by the solar wind?

- A** $3.1 \times 10^{-8} \text{ m s}^{-2}$
B $6.3 \times 10^{-7} \text{ m s}^{-2}$
C $3.2 \times 10^{-3} \text{ m s}^{-2}$
D $6.4 \times 10^{-2} \text{ m s}^{-2}$
-

491. 9702_s16_qp_13 Q: 15

For a change in depth Δh in a liquid of density ρ , the change in pressure Δp is given by $\Delta p = \Delta h \rho g$ where g is the acceleration of free fall.

What is the equation, or principle of physics, used in the derivation of this formula?

- A** atmospheric pressure decreases with height
- B** change in gravitational potential energy = mass $\times g \Delta h$
- C** $\rho = \frac{\text{mass}}{\text{volume}}$
- D** the density of a fluid increases with depth

492. 9702_w16_qp_11 Q: 14

A submarine has circular windows of diameter 0.30 m. The windows can experience a maximum external pressure of 660 kPa before they crack.

What is the minimum external force needed to crack the windows?

- A** 47 000 N **B** 190 000 N **C** 310 000 N **D** 620 000 N

493. 9702_w16_qp_13 Q: 14

A submarine has circular windows of diameter 0.30 m. The windows can experience a maximum external pressure of 660 kPa before they crack.

What is the minimum external force needed to crack the windows?

- A** 47 000 N **B** 190 000 N **C** 310 000 N **D** 620 000 N

494. 9702_s15_qp_12 Q: 20

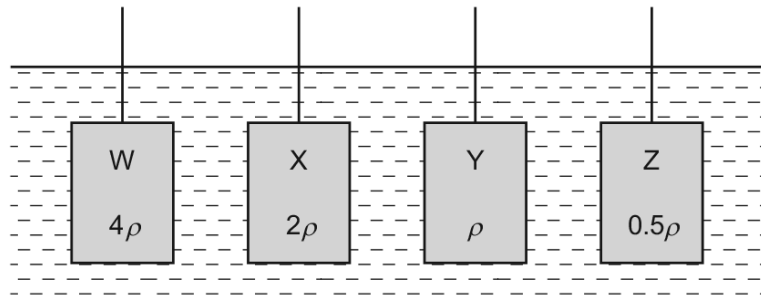
The maximum pressure that granite rock can withstand is $2.0 \times 10^8 \text{ N m}^{-2}$. Above this pressure, the rock begins to flow like a liquid. The density of granite is $2.7 \times 10^3 \text{ kg m}^{-3}$.

What would be the height of a pure granite mountain whose base is just beginning to flow?

- A** $3.8 \times 10^3 \text{ m}$ **B** $7.6 \times 10^3 \text{ m}$ **C** $3.7 \times 10^4 \text{ m}$ **D** $7.4 \times 10^4 \text{ m}$

495. 9702_s15_qp_13 Q: 14

Four cuboids with identical length, breadth and height are immersed in water. The cuboids are held at the same depth and in identical orientations by vertical rods, as shown.



Water has density ρ .

Cuboid W is made of material of density 4ρ .

Cuboid X is made of material of density 2ρ .

Cuboid Y is made of material of density ρ .

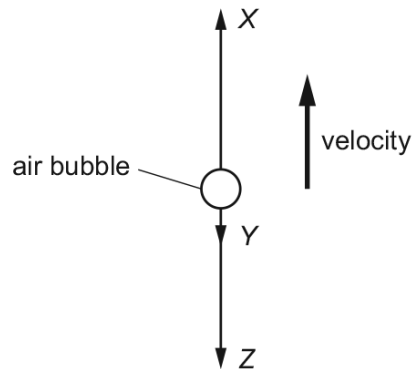
Cuboid Z is made of material of density 0.5ρ .

Which statement is correct?

- A** The upthrust of the water on each of the cuboids is the same.
- B** The upthrust of the water on W is twice the upthrust of the water on X.
- C** The upthrust of the water on X is twice the upthrust of the water on W.
- D** The upthrust of the water on Y is zero.

496. 9702_s15_qp_13 Q: 15

An air bubble in a tank of water is rising with constant velocity. The forces acting on the bubble are X, Y and Z as shown.



What describes the three forces?

- A** Z is the viscous drag on the bubble, Y is the weight of the bubble, X is the upthrust on the bubble and $X = Y + Z$.
- B** Z is the viscous drag on the bubble, Y is the weight of the bubble, X is the upthrust on the bubble and $X > Y + Z$.
- C** Z is the weight of the bubble, Y is the viscous drag on the bubble, X is the upthrust on the bubble and $X = Y + Z$.
- D** Z is the weight of the bubble, Y is the viscous drag on the bubble, X is the upthrust on the bubble and $X > Y + Z$.

497. 9702_s15_qp_13 Q: 20

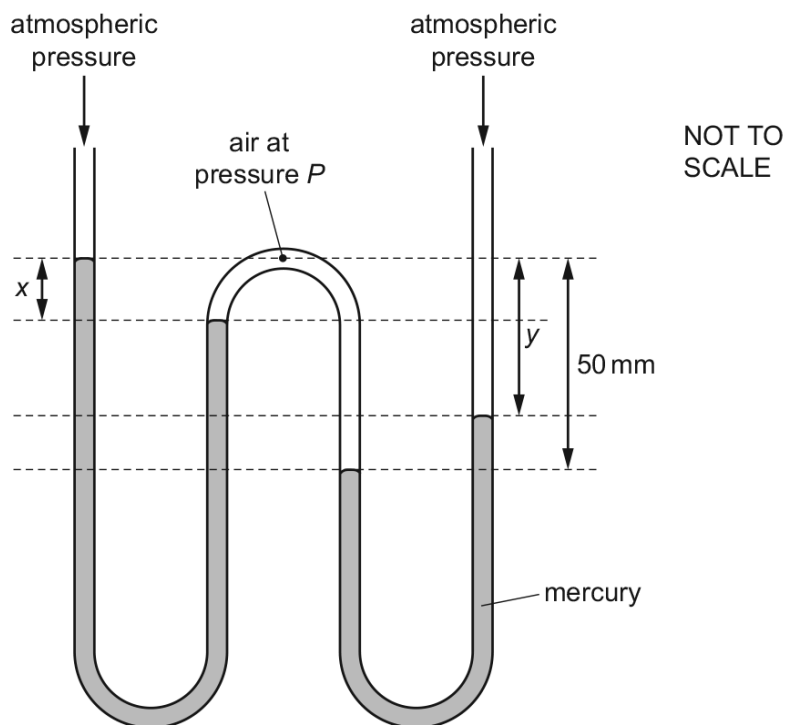
When ice melts, it contracts.

Which row is correct for ice turning into water?

	distance between molecules	density
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

498. 9702_s15_qp_13 Q: 21

A W-shaped tube contains two amounts of mercury, each open to the atmosphere. Air at pressure P is trapped in between them. The diagram shows two vertical distances x and y .



Atmospheric pressure is equal to the pressure that would be exerted by a column of mercury of height 760 mm. The pressure P is expressed in this way.

Which values of x , y and P are possible?

	x/mm	y/mm	$P/\text{mm of mercury}$
A	20	20	780
B	20	30	780
C	30	20	810
D	30	30	790

Paper 1 Multiple Choice Answers: Forces, Density and Pressure

Question	Paper	Q. No.	Answer
364	9702_m20_qp_12	11	A
365	9702_s20_qp_12	10	B
366	9702_m19_qp_12	11	C
367	9702_s19_qp_12	12	D
368	9702_w19_qp_12	10	A
369	9702_m18_qp_12	12	A
370	9702_s18_qp_12	11	C
371	9702_w18_qp_11	10	A
372	9702_w18_qp_12	11	D
373	9702_w18_qp_13	11	A
374	9702_m17_qp_12	13	C
375	9702_m17_qp_12	15	B
376	9702_s17_qp_11	11	A
377	9702_s17_qp_12	10	A
378	9702_s17_qp_13	12	A
379	9702_w17_qp_11	8	B
380	9702_w17_qp_11	12	A
381	9702_w17_qp_12	11	D
382	9702_w17_qp_13	11	B
383	9702_s16_qp_13	13	B
384	9702_w16_qp_12	14	D
385	9702_s15_qp_12	12	C
386	9702_m20_qp_12	12	A
387	9702_s20_qp_11	12	A
388	9702_s20_qp_11	13	C
389	9702_s20_qp_12	11	B
390	9702_s20_qp_13	12	B
391	9702_m19_qp_12	12	D
392	9702_s19_qp_11	13	C
393	9702_s19_qp_13	13	A
394	9702_w19_qp_11	12	A
395	9702_w19_qp_13	11	A
396	9702_m18_qp_12	11	A
397	9702_s18_qp_11	10	A
398	9702_s18_qp_11	12	D
399	9702_s18_qp_12	13	A
400	9702_s18_qp_12	14	C
401	9702_s18_qp_13	12	D
402	9702_w18_qp_13	12	B
403	9702_m17_qp_12	12	B
404	9702_s17_qp_11	12	D
405	9702_s17_qp_12	11	C
406	9702_w17_qp_11	13	A
407	9702_w17_qp_12	12	B
408	9702_w17_qp_13	12	B
409	9702_m16_qp_12	13	B

Paper 1 Multiple Choice Answers: Forces, Density and Pressure (contin

Question	Paper	Q. No.	Answer
410	9702_sl6_qp_12	14	D
411	9702_sl6_qp_13	14	B
412	9702_wl6_qp_12	15	C
413	9702_wl6_qp_12	17	C
414	9702_m20_qp_12	13	B
415	9702_s20_qp_11	14	D
416	9702_s20_qp_12	12	A
417	9702_s20_qp_13	13	A
418	9702_s20_qp_13	14	D
419	9702_sl9_qp_11	14	C
420	9702_sl9_qp_11	15	D
421	9702_sl9_qp_13	12	C
422	9702_wl9_qp_11	13	C
423	9702_wl9_qp_12	11	A
424	9702_wl9_qp_12	12	D
425	9702_wl9_qp_13	12	A
426	9702_m18_qp_12	13	C
427	9702_sl8_qp_12	15	D
428	9702_sl8_qp_12	17	C
429	9702_wl8_qp_11	11	C
430	9702_wl8_qp_11	12	A
431	9702_wl8_qp_12	12	C
432	9702_wl8_qp_12	13	A
433	9702_wl8_qp_13	13	D
434	9702_m17_qp_12	11	B
435	9702_m17_qp_12	14	C
436	9702_sl7_qp_11	13	C
437	9702_sl7_qp_12	12	D
438	9702_sl7_qp_13	11	D
439	9702_sl7_qp_13	13	A
440	9702_wl7_qp_11	14	B
441	9702_wl7_qp_12	13	D
442	9702_wl7_qp_12	14	A
443	9702_m16_qp_12	12	A
444	9702_sl6_qp_11	11	C
445	9702_sl6_qp_11	12	A
446	9702_sl6_qp_11	14	B
447	9702_sl6_qp_12	12	D
448	9702_wl6_qp_11	15	D
449	9702_wl6_qp_11	16	B
450	9702_wl6_qp_13	15	D
451	9702_wl6_qp_13	16	B
452	9702_sl5_qp_11	15	C
453	9702_sl5_qp_12	14	B
454	9702_sl5_qp_13	16	A
455	9702_s20_qp_11	15	B

Paper 1 Multiple Choice Answers: Forces, Density and Pressure (contin

Question	Paper	Q. No.	Answer
456	9702_s20_qp_12	13	B
457	9702_s20_qp_13	11	B
458	9702_s20_qp_13	15	B
459	9702_m19_qp_12	14	D
460	9702_s19_qp_11	12	A
461	9702_s19_qp_11	16	A
462	9702_s19_qp_12	15	D
463	9702_s19_qp_12	21	C
464	9702_s19_qp_13	14	D
465	9702_w19_qp_11	11	D
466	9702_w19_qp_11	14	A
467	9702_w19_qp_12	13	B
468	9702_w19_qp_13	10	B
469	9702_w19_qp_13	13	B
470	9702_m18_qp_12	4	B
471	9702_s18_qp_11	11	D
472	9702_s18_qp_11	13	C
473	9702_s18_qp_12	10	D
474	9702_s18_qp_12	12	B
475	9702_s18_qp_13	10	A
476	9702_s18_qp_13	11	D
477	9702_s18_qp_13	13	B
478	9702_w18_qp_11	13	C
479	9702_w18_qp_12	14	C
480	9702_w18_qp_13	14	D
481	9702_s17_qp_11	14	A
482	9702_s17_qp_12	13	D
483	9702_w17_qp_12	15	B
484	9702_w17_qp_13	14	A
485	9702_m16_qp_12	14	B
486	9702_s16_qp_11	13	B
487	9702_s16_qp_11	15	C
488	9702_s16_qp_12	13	A
489	9702_s16_qp_12	15	C
490	9702_s16_qp_13	11	B
491	9702_s16_qp_13	15	C
492	9702_w16_qp_11	14	A
493	9702_w16_qp_13	14	A
494	9702_s15_qp_12	20	B
495	9702_s15_qp_13	14	A
496	9702_s15_qp_13	15	A
497	9702_s15_qp_13	20	B
498	9702_s15_qp_13	21	B

Chapter 5

Forces, density and pressure

5.1 Types of force

43. 9702_s18_qp_21 Q: 3

- (a) State what is meant by the *mass* of a body.

.....
[1]

- (b) Two blocks travel directly towards each other along a horizontal, frictionless surface. The blocks collide, as illustrated in Fig. 3.1.

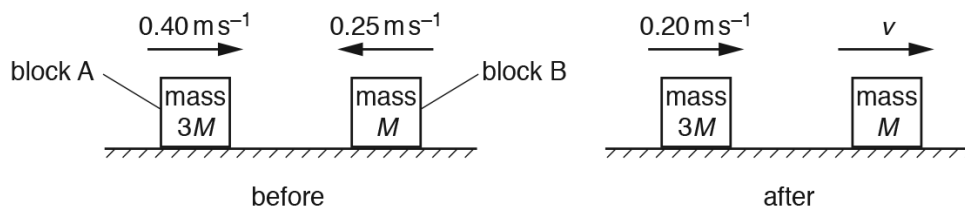


Fig. 3.1

Block A has mass $3M$ and block B has mass M .

Before the collision, block A moves to the right with speed 0.40 m s^{-1} and block B moves to the left with speed 0.25 m s^{-1} .

After the collision, block A moves to the right with speed 0.20 m s^{-1} and block B moves to the right with speed v .

- (i) Use Newton's third law to explain why, during the collision, the change in momentum of block A is equal and opposite to the change in momentum of block B.

.....

[2]

- (ii) Determine speed v .

$v = \dots\dots\dots \text{ m s}^{-1}$ [3]

(iii) Calculate, for the blocks,

1. the relative speed of approach,

relative speed of approach = ... ms^{-1}

2. the relative speed of separation.

relative speed of separation = ... ms^{-1}
[2]

(iv) Use your answers in (b)(iii) to state and explain whether the collision is elastic or inelastic.

.....
.....[1]

[Total: 9]

44. 9702_m17_qp_22 Q: 1

- (a) Complete Fig. 1.1 by putting a tick (✓) in the appropriate column to indicate whether the listed quantities are scalars or vectors.

quantity	scalar	vector
acceleration		
force		
kinetic energy		
momentum		
power		
work		

Fig. 1.1

[2]

- (b) A floating sphere is attached by a cable to the bottom of a river, as shown in Fig. 1.2.

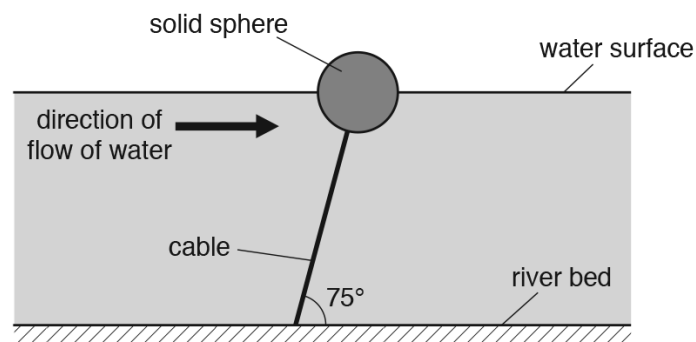


Fig. 1.2

The sphere is in equilibrium, with the cable at an angle of 75° to the horizontal. Assume that the force on the sphere due to the water flow is in the horizontal direction.

The radius of the sphere is 23 cm. The sphere is solid and is made from a material of density 82 kg m^{-3} .

- (i) Show that the weight of the sphere is 41 N.

[2]

- (ii) The tension in the cable is 290 N.

Determine the upthrust acting on the sphere.

upthrust = ... N [2]

- (iii) Explain the origin of the upthrust acting on the sphere.

.....
.....
.....[1]

[Total: 7]

45. 9702_s16_qp_21 Q: 3

A ball of mass 150 g is at rest on a horizontal floor, as shown in Fig. 3.1.

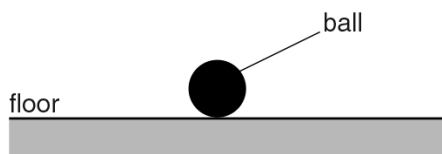


Fig. 3.1

- (a) (i) Calculate the magnitude of the normal contact force from the floor acting on the ball.

force = ... N [1]

- (ii) Explain your working in (i).

.....

[1]

- (b) The ball is now lifted above the floor and dropped so that it falls vertically, as illustrated in Fig. 3.2.

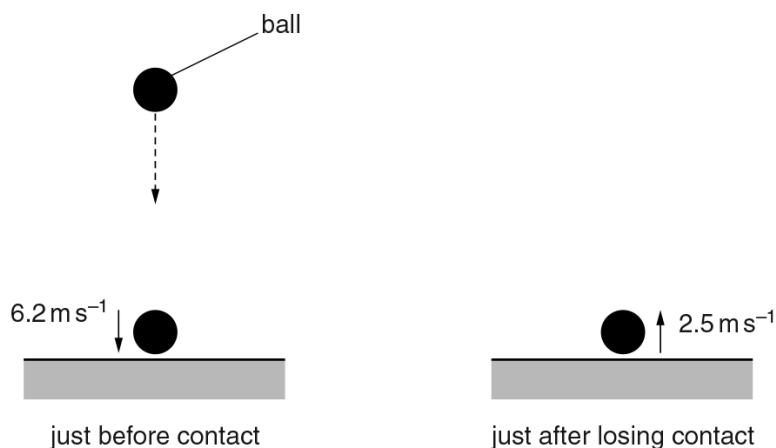


Fig. 3.2

Just before contact with the floor, the ball has velocity 6.2 m s^{-1} downwards. The ball bounces from the floor and its velocity just after losing contact with the floor is 2.5 m s^{-1} upwards. The ball is in contact with the floor for 0.12 s.

- (i) State Newton's second law of motion.

.....
.....[1]

- (ii) Calculate the average resultant force on the ball when it is in contact with the floor.

magnitude of force = ... N

direction of force
[3]

- (iii) State and explain whether linear momentum is conserved during the collision of the ball with the floor.

.....
.....
.....
.....[2]

[Total: 8]

5.2 Turning effects of forces

46. 9702_w19_qp_22 Q: 4

- (a) A sphere in a liquid accelerates vertically downwards from rest. For the viscous force acting on the moving sphere, state:

(i) the direction

..... [1]

(ii) the variation, if any, in the magnitude.

..... [1]

- (b) A man of weight 750 N stands a distance of 3.6 m from end D of a horizontal uniform beam AD, as shown in Fig. 4.1.

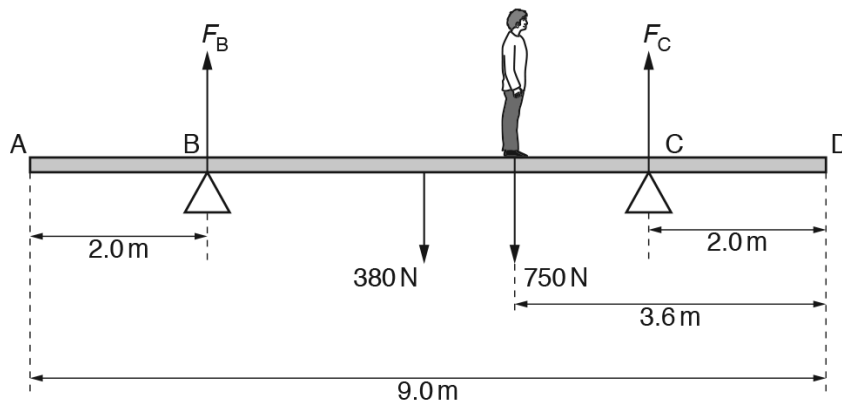


Fig. 4.1 (not to scale)

The beam has a weight of 380 N and a length of 9.0 m. The beam is supported by a vertical force F_B at pivot B and a vertical force F_C at pivot C. Pivot B is a distance of 2.0 m from end A and pivot C is a distance of 2.0 m from end D. The beam is in equilibrium.

- (i) State the principle of moments.

.....

.....

..... [2]

- (ii) By using moments about pivot C, calculate F_B .

$$F_B = \dots\dots\dots \text{ N [2]}$$

- (iii) The man walks towards end D. The beam is about to tip when F_B becomes zero.

Determine the minimum distance x from end D that the man can stand without tipping the beam.

$$x = \dots\dots\dots \text{ m [2]}$$

[Total: 8]

47. 9702_w19_qp_23 Q: 1

- (a) Determine the SI base units of the moment of a force.

SI base units [1]

- (b) A uniform square sheet of card ABCD is freely pivoted by a pin at a point P. The card is held in a vertical plane by an external force in the position shown in Fig. 1.1.

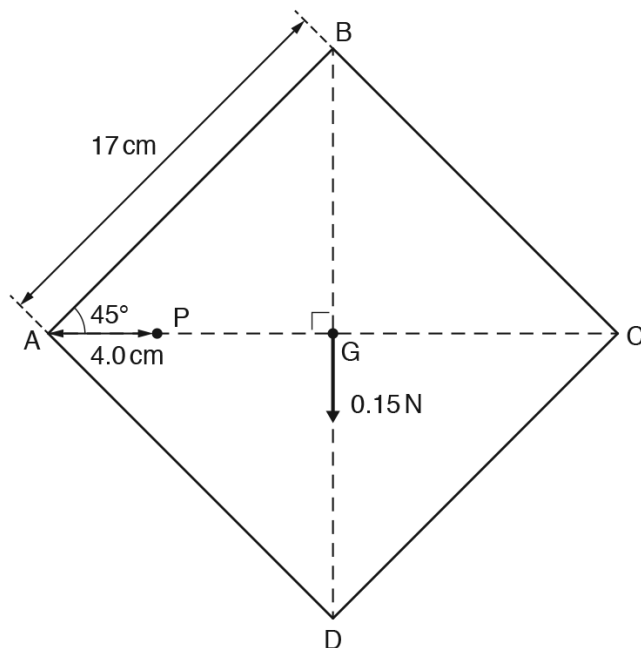


Fig. 1.1 (not to scale)

The card has weight 0.15 N which may be considered to act at the centre of gravity G. Each side of the card has length 17 cm. Point P lies on the horizontal line AC and is 4.0 cm from corner A. Line BD is vertical.

The card is released by removing the external force. The card then swings in a vertical plane until it comes to rest.

- (i) Calculate the magnitude of the resultant moment about point P acting on the card immediately after it is released.

moment = ... Nm [2]

- (ii) Explain why, when the card has come to rest, its centre of gravity is vertically below point P.

.....
.....
.....
..... [2]

[Total: 5]

48. 9702_w17_qp_22 Q: 2

- (a) Define the *moment* of a force.

.....
[1]

- (b) A thin disc of radius r is supported at its centre O by a pin. The disc is supported so that it is vertical. Three forces act in the plane of the disc, as shown in Fig. 2.1.

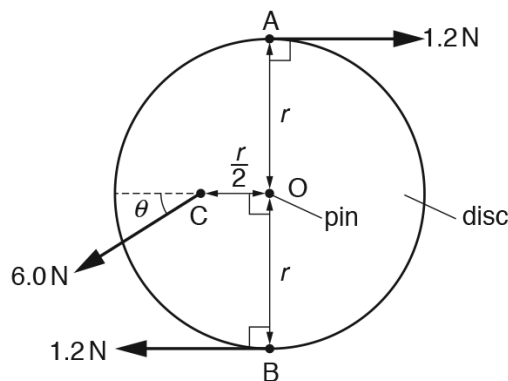


Fig. 2.1

Two horizontal and opposite forces, each of magnitude 1.2 N, act at points A and B on the edge of the disc. A force of 6.0 N, at an angle θ below the horizontal, acts on the midpoint C of a radial line of the disc, as shown in Fig. 2.1. The disc has negligible weight and is in equilibrium.

- (i) State an expression, in terms of r , for the torque of the couple due to the forces at A and B acting on the disc.

.....[1]

- (ii) Friction between the disc and the pin is negligible.
 Determine the angle θ .

$\theta = \dots\dots\dots^\circ$ [2]

- (iii) State the magnitude of the force of the pin on the disc.

force = ... N [1]

[Total: 5]

5.3 Equilibrium of forces

49. 9702_s20_qp_23 Q: 2

- (a) State Newton's first law of motion.

.....
 [1]

- (b) A skier is pulled in a straight line along horizontal ground by a wire attached to a kite, as shown in Fig. 2.1.

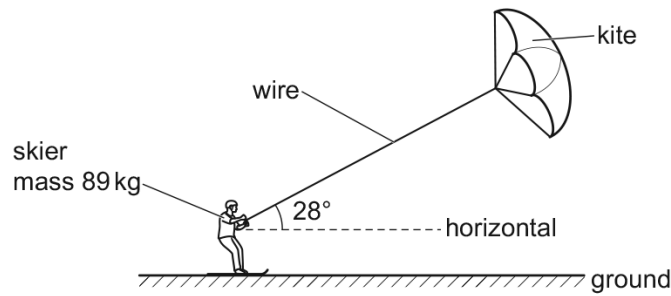


Fig. 2.1 (not to scale)

The mass of the skier is 89 kg. The wire is at an angle of 28° to the horizontal. The variation with time t of the velocity v of the skier is shown in Fig. 2.2.

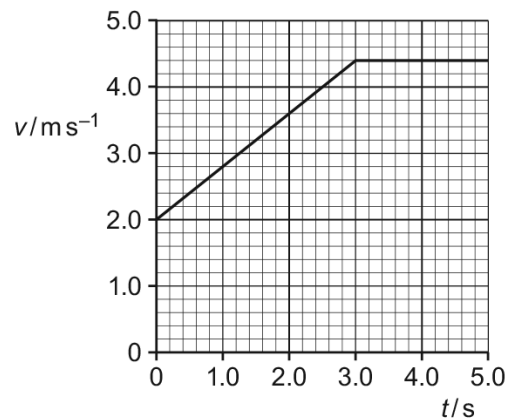


Fig. 2.2

- (i) Use Fig. 2.2 to determine the distance moved by the skier from time $t = 0$ to $t = 5.0$ s.

distance = ... m [2]

- (ii) Use Fig. 2.2 to show that the acceleration a of the skier is 0.80 m s^{-2} at time $t = 2.0 \text{ s}$.

[2]

- (iii) The tension in the wire at time $t = 2.0 \text{ s}$ is 240 N .

Calculate:

1. the horizontal component of the tension force acting on the skier

horizontal component of force = ... N [1]

2. the total resistive force R acting on the skier in the horizontal direction.

$R =$ N [2]

- (iv) The skier is now lifted upwards by a gust of wind. For a few seconds the skier moves horizontally through the air with the wire at an angle of 45° to the horizontal, as shown in Fig. 2.3.

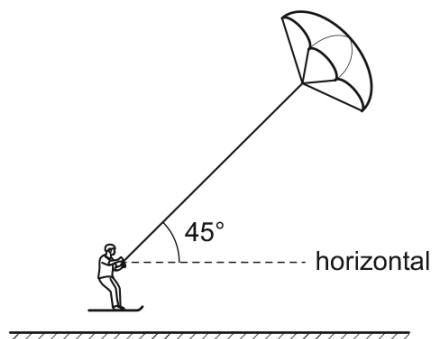


Fig. 2.3 (not to scale)

By considering the vertical components of the forces acting on the skier, determine the new tension in the wire when the skier is moving horizontally through the air.

tension = ... N [2]

[Total: 10]

50. 9702_w20_qp_22 Q: 4

A rigid plank is used to make a ramp between two different horizontal levels of ground, as shown in Fig. 4.1.

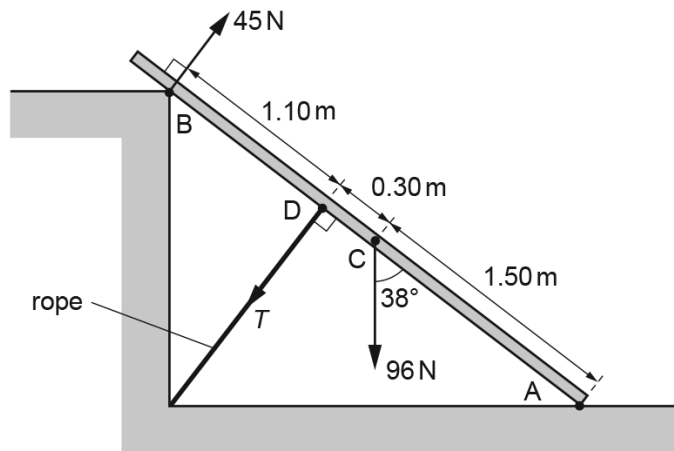


Fig. 4.1 (not to scale)

Point A at one end of the plank rests on the lower level of the ground. A force acts on, and is perpendicular to, the plank at point B. The plank is held in equilibrium by a rope that connects point D on the plank to the ground. The plank has a weight that may be considered to act from its centre of gravity C.

The rope is perpendicular to the plank and has tension T . The plank is at an angle of 38° to the vertical.

The forces and the distances along the plank of points A, B, C and D are shown in Fig. 4.1.

(a) Show that the component of the weight that is perpendicular to the plank is 59 N.

[1]

(b) By taking moments about end A of the plank, calculate the tension T .

$T = \dots\dots\dots$ N [3]

[Total: 4]

51. 9702_w20_qp_23 Q: 2

- (a) State what is meant by the *centre of gravity* of a body.

.....

 [2]

- (b) A uniform wooden post AB of weight 45 N stands in equilibrium on hard ground, as shown in Fig. 2.1.

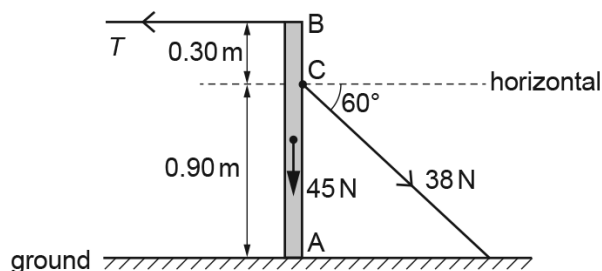


Fig. 2.1 (not to scale)

End A of the vertical post is supported by the ground. A horizontal wire with tension T is attached to end B of the post. Another wire, attached to the post at point C, is at an angle of 60° to the horizontal and has tension 38 N. The distances along the post of points A, B and C are shown in Fig. 2.1.

- (i) Calculate the horizontal component of the force exerted on the post by the wire connected to point C.

horizontal component of force = ... N [1]

- (ii) By considering moments about end A, determine the tension T .

T = ... N [2]

- (iii) Calculate the vertical component of the force exerted on the post at end A.

force = ... N [1]

[Total: 6]

52. 9702_w18_qp_22 Q: 2

- (a) The kilogram, metre and second are all SI base units.

State two other SI base units.

1.

2. [2]

- (b) A uniform beam AB of length 6.0 m is placed on a horizontal surface and then tilted at an angle of 31° to the horizontal, as shown in Fig. 2.1.

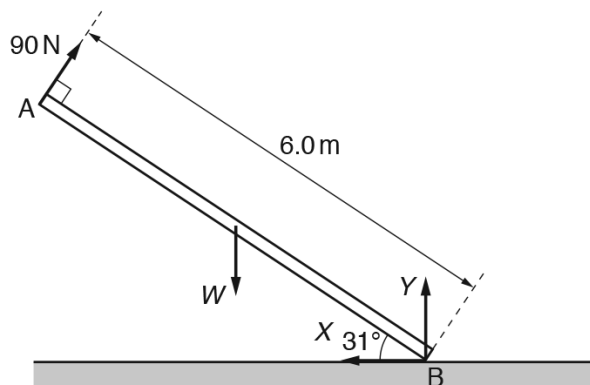


Fig. 2.1 (not to scale)

The beam is held in equilibrium by four forces that all act in the same plane. A force of 90 N acts perpendicular to the beam at end A. The weight W of the beam acts at its centre of gravity. A vertical force Y and a horizontal force X both act at end B of the beam.

- (i) State the name of force X .

..... [1]

- (ii) By taking moments about end B, calculate the weight W of the beam.

$W =$ N [2]

- (iii) Determine the magnitude of force X .

magnitude of force $X =$ N [1]

[Total: 6]

53. 9702_s15_qp_22 Q: 3

A rod PQ is attached at P to a vertical wall, as shown in Fig. 3.1.

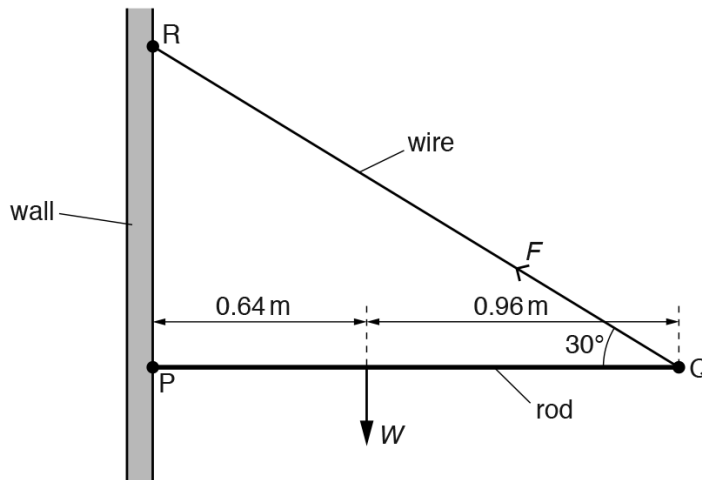


Fig. 3.1

The length of the rod is 1.60 m. The weight W of the rod acts 0.64 m from P. The rod is kept horizontal and in equilibrium by a wire attached to Q and to the wall at R. The wire provides a force F on the rod of 44 N at 30° to the horizontal.

(a) Determine

(i) the vertical component of F ,

vertical component = ... N [1]

(ii) the horizontal component of F .

horizontal component = ... N [1]

(b) By taking moments about P, determine the weight W of the rod.

$W =$ N [2]

- (c) Explain why the wall must exert a force on the rod at P.

.....
.....
..... [1]

- (d) On Fig. 3.1, draw an arrow to represent the force acting on the rod at P. Label your arrow with the letter S. [1]

54. 9702_w15_qp_22 Q: 4

(a) Define *moment of a force*.

.....
[1]

(b) An arrangement for lifting heavy loads is shown in Fig. 4.1.

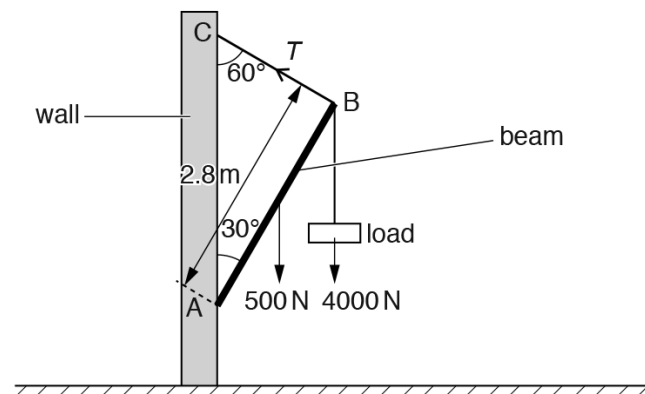


Fig. 4.1

A uniform metal beam AB is pivoted on a vertical wall at A. The beam is supported by a wire joining end B to the wall at C. The beam makes an angle of 30° with the wall and the wire makes an angle of 60° with the wall.

The beam has length 2.8 m and weight of 500 N . A load of 4000 N is supported from B. The tension in the wire is T . The beam is in equilibrium.

(i) By taking moments about A, show that T is 2.1 kN .

[2]

(ii) Calculate the vertical component T_v of the tension T .

$$T_v = \dots\dots\dots \text{ N [1]}$$

(iii) State and explain why T_v does not equal the sum of the load and the weight of the beam although the beam is in equilibrium.

.....
[2]

5.4 Density and pressure

55. 9702_w20_qp_21 Q: 1

- (a) (i) Define the *moment* of a force about a point.

.....
 [1]

- (ii) Determine the SI base units of the moment of a force.

base units [1]

- (b) A uniform rigid rod of length 2.4 m is shown in Fig. 1.1.

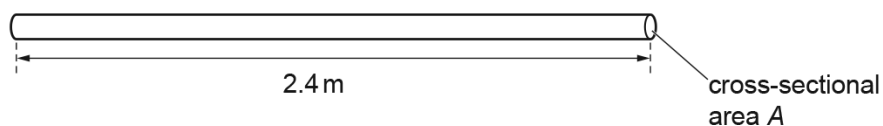


Fig. 1.1

The rod has a weight of 5.2 N and is made of wood of density 790 kg m^{-3} .

Calculate the cross-sectional area A , in mm^2 , of the rod.

$A = \dots\dots\dots \text{mm}^2$ [3]

- (c) A fishing rod AB, made from the rod in (b), is shown in Fig. 1.2.

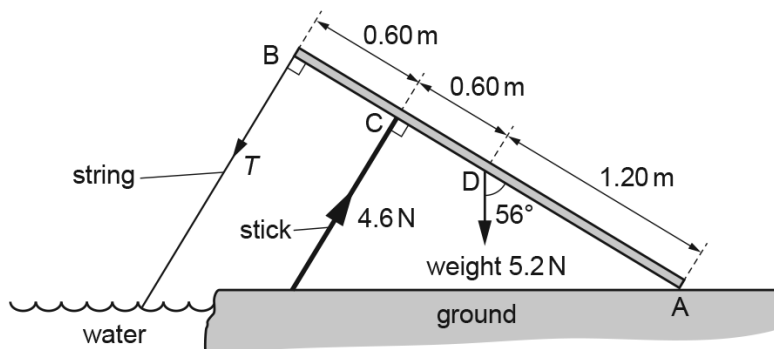


Fig. 1.2 (not to scale)

End A of the rod rests on the ground and a string is attached to the other end B. A support stick exerts a force perpendicular to the rod at point C. The weight of the rod acts at point D.

The tension T in the string is in a direction perpendicular to the rod. The rod is in equilibrium and inclined at an angle of 56° to the vertical.

The forces and the distances along the rod of points A, B, C and D are shown in Fig. 1.2.

- (i) Show that the component of the weight that is perpendicular to the rod is 4.3 N.

[1]

- (ii) By taking moments about end A of the rod, calculate the tension T .

$T = \dots\dots\dots$ N [3]

[Total: 9]

56. 9702_w20_qp_22 Q: 2

- (a) A cylinder is suspended from the end of a string. The cylinder is stationary in water with the axis of the cylinder vertical, as shown in Fig. 2.1.

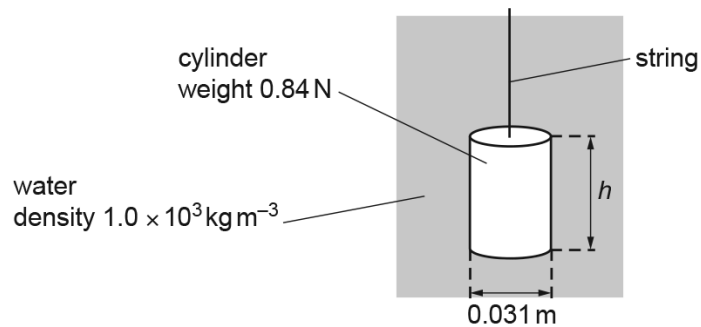


Fig. 2.1 (not to scale)

The cylinder has weight 0.84 N, height h and a circular cross-section of diameter 0.031 m. The density of the water is $1.0 \times 10^3 \text{ kg m}^{-3}$. The difference between the pressures on the top and bottom faces of the cylinder is 520 Pa.

- (i) Calculate the height h of the cylinder.

$h = \dots\dots\dots \text{ m}$ [2]

- (ii) Show that the upthrust acting on the cylinder is 0.39 N.

[2]

- (iii) Calculate the tension T in the string.

$T = \dots\dots\dots \text{ N}$ [1]

- (b) The string is now used to move the cylinder in (a) vertically upwards through the water. The variation with time t of the velocity v of the cylinder is shown in Fig. 2.2.

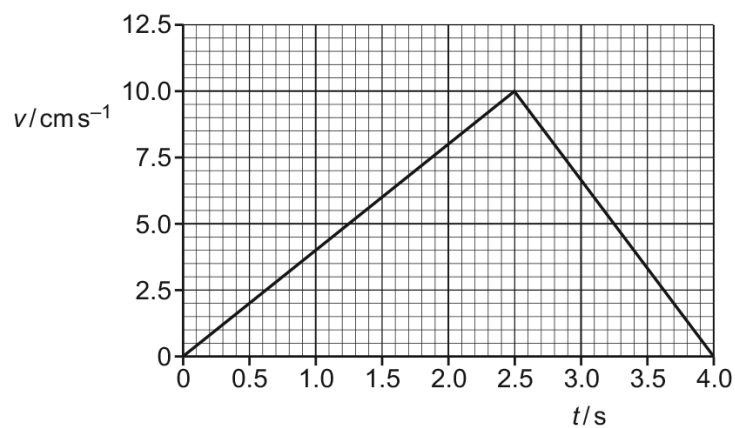


Fig. 2.2

- (i) Use Fig. 2.2 to determine the acceleration of the cylinder at time $t = 2.0$ s.

acceleration = ... ms^{-2} [2]

- (ii) The top face of the cylinder is at a depth of 0.32 m below the surface of the water at time $t = 0$.

Use Fig. 2.2 to determine the depth of the top face below the surface of the water at time $t = 4.0$ s.

depth = ... m [2]

(c) The cylinder in (b) is released from the string at time $t = 4.0\text{ s}$. The cylinder falls, from rest, vertically downwards through the water. Assume that the upthrust acting on the cylinder remains constant as it falls.

- (i) State the name of the force that acts on the cylinder when it is moving and does not act on the cylinder when it is stationary.

..... [1]

- (ii) State and explain the variation, if any, of the acceleration of the cylinder as it falls downwards through the water.

.....

.....

..... [2]

[Total: 12]

57. 9702_w18_qp_22 Q: 3

- (a) State the principle of conservation of momentum.

.....

[2]

- (b) The propulsion system of a toy car consists of a propeller attached to an electric motor, as illustrated in Fig. 3.1.

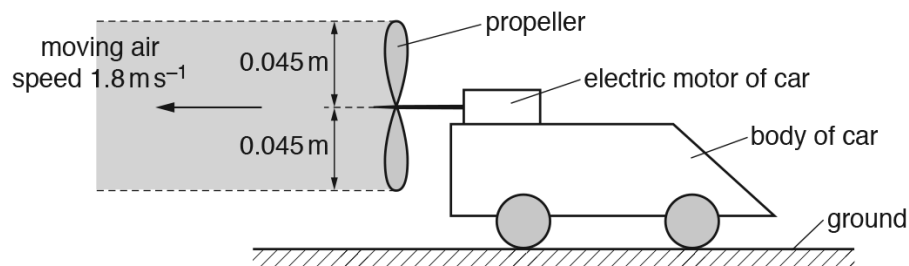


Fig. 3.1

The car is on horizontal ground and is initially held at rest by its brakes. When the motor is switched on, it rotates the propeller so that air is propelled horizontally to the left. The density of the air is 1.3 kg m^{-3} .

Assume that the air moves with a speed of 1.8 ms^{-1} in a uniform cylinder of radius 0.045 m . Also assume that the air to the right of the propeller is stationary.

- (i) Show that, in a time interval of 2.0 s , the mass of air propelled to the left is 0.030 kg .

[2]

(ii) Calculate

1. the increase in the momentum of the mass of air in (b)(i),

increase in momentum = ... N s

2. the force exerted on this mass of air by the propeller.

force = ... N
[3]

(iii) Explain how Newton's third law applies to the movement of the air by the propeller.

.....
.....
.....[2]

(iv) The total mass of the car is 0.20 kg. The brakes of the car are released and the car begins to move with an initial acceleration of 0.075 m s^{-2} .

Determine the initial frictional force acting on the car.

frictional force = ... N [2]

[Total: 11]

58. 9702_w18_qp_23 Q: 3

- (a) State Newton's second law of motion.

.....
[1]

- (b) A toy rocket consists of a container of water and compressed air, as shown in Fig. 3.1.

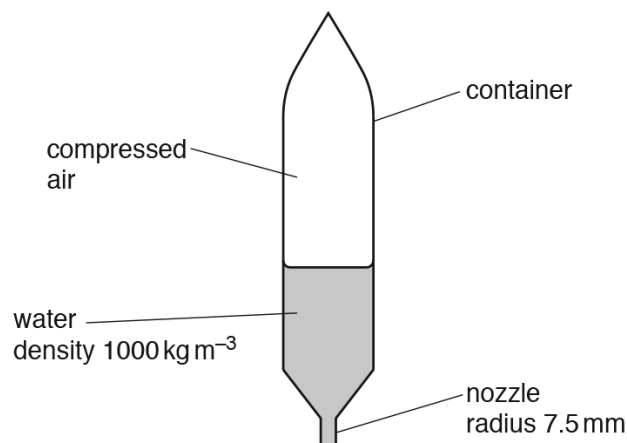


Fig. 3.1

Water is pushed vertically downwards through a nozzle by the compressed air. The rocket moves vertically upwards.

The nozzle has a circular cross-section of radius 7.5 mm. The density of the water is 1000 kg m^{-3} . Assume that the water leaving the nozzle has the shape of a cylinder of radius 7.5 mm and has a constant speed of 13 m s^{-1} relative to the rocket.

- (i) Show that the mass of water leaving the nozzle in the first 0.20 s after the rocket launch is 0.46 kg.

[2]

(ii) Calculate

1. the change in the momentum of the mass of water in **(b)(i)** due to leaving the nozzle,

change in momentum = ...Ns

2. the force exerted on this mass of water by the rocket.

force = ... N
[3]

(iii) State and explain how Newton's third law applies to the movement of the rocket by the water.

.....
.....
.....[2]

(iv) The container has a mass of 0.40kg. The initial mass of water before the rocket is launched is 0.70 kg. The mass of the compressed air in the rocket is negligible. Assume that the resistive force on the rocket due to its motion is negligible.

For the rocket at a time of 0.20s after launching,

1. show that its total mass is 0.64 kg,

2. calculate its acceleration.

acceleration = ... ms^{-2}
[3]

[Total: 11]

59. 9702_s17_qp_21 Q: 3

- (a) A cylinder is made from a material of density 2.7 g cm^{-3} . The cylinder has diameter 2.4 cm and length 5.0 cm .

Show that the cylinder has weight 0.60 N .

[3]

- (b) The cylinder in (a) is hung from the end A of a non-uniform bar AB, as shown in Fig. 3.1.

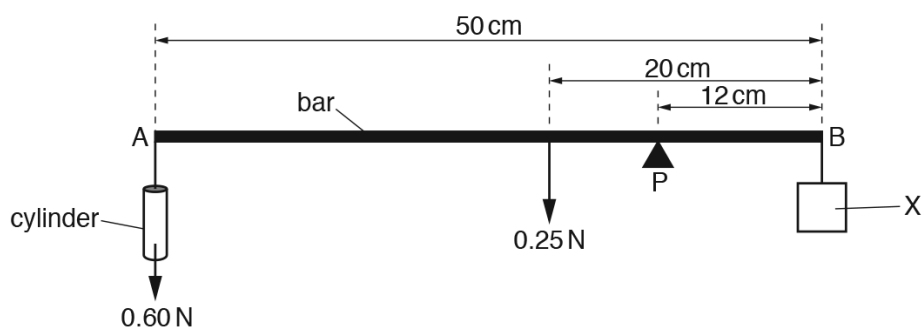


Fig. 3.1

The bar has length 50 cm and has weight 0.25 N . The centre of gravity of the bar is 20 cm from B. The bar is pivoted at P. The pivot is 12 cm from B.

An object X is hung from end B. The weight of X is adjusted until the bar is horizontal and in equilibrium.

- (i) Explain what is meant by *centre of gravity*.

.....
[1]

- (ii) Calculate the weight of X.

weight of X = ... N [3]

- (c) The cylinder is now immersed in water, as illustrated in Fig. 3.2.

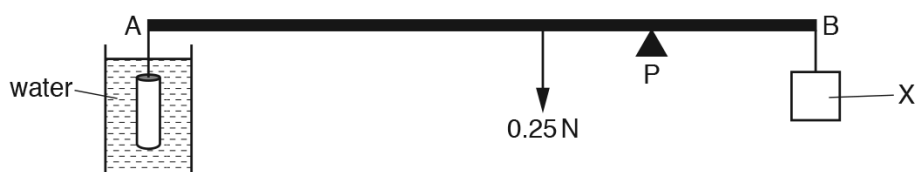


Fig. 3.2

An upthrust acts on the cylinder and the bar is not in equilibrium.

- (i) Explain the origin of the upthrust.

.....
.....
.....
.....[2]

- (ii) Explain why the weight of X must be reduced in order to obtain equilibrium for AB.

.....
.....
.....[1]

[Total: 10]

60. 9702_s16_qp_22 Q: 2

(a) Fig. 2.1 shows a liquid in a cylindrical container.

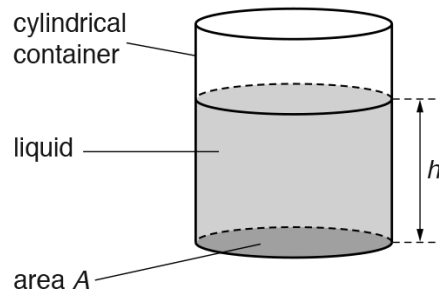


Fig. 2.1

The cross-sectional area of the container is A . The height of the column of liquid is h and the density of the liquid is ρ .

Show that the pressure p due to the liquid on the base of the cylinder is given by

$$p = \rho gh.$$

[3]

- (b) The variation with height h of the total pressure P on the base of the cylinder in (a) is shown in Fig. 2.2.

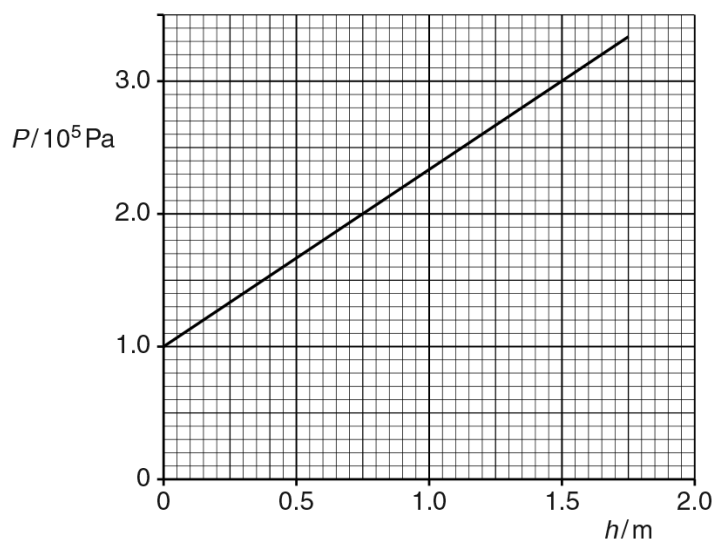


Fig. 2.2

- (i) Explain why the line of the graph in Fig. 2.2 does not pass through the origin (0,0).

.....
[1]

- (ii) Use data from Fig. 2.2 to calculate the density of the liquid in the cylinder.

density = ... kg m^{-3} [2]

[Total: 6]

61. 9702_s16_qp_23 Q: 4

A spring balance is used to weigh a cylinder that is immersed in oil, as shown in Fig. 4.1.

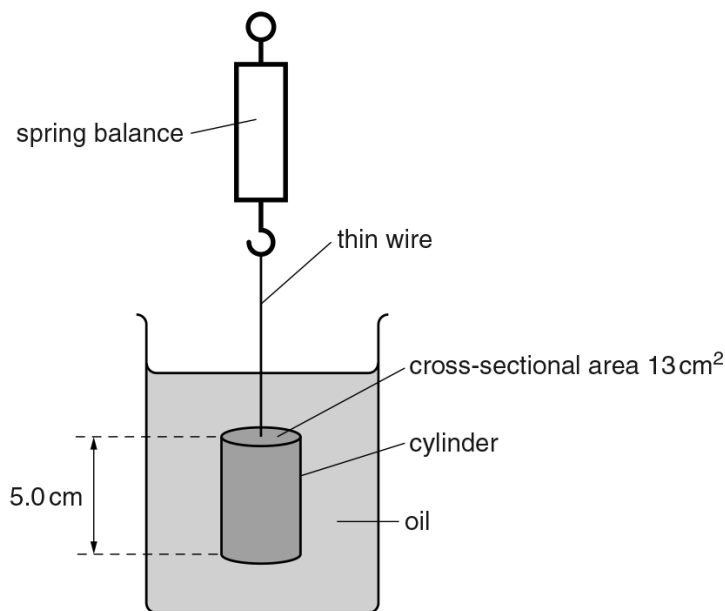


Fig. 4.1

The reading on the spring balance is 4.8 N. The length of the cylinder is 5.0 cm and the cross-sectional area of the cylinder is 13 cm². The weight of the cylinder is 5.3 N.

- (a) The cylinder is in equilibrium when it is immersed in the oil. Explain this in terms of the forces acting on the cylinder.

.....
 [1]

- (b) Calculate the density of the oil.

density = ... kg m⁻³ [3]

[Total: 4]

62. 9702_w16_qp_21 Q: 1

(a) Define *density*.

.....

.....[1]

(b) The mass m of a metal sphere is given by the expression

$$m = \frac{\pi d^3 \rho}{6}$$

where ρ is the density of the metal and d is the diameter of the sphere.

Data for the density and the mass are given in Fig. 1.1.

quantity	value	uncertainty
ρ	8100 kg m ⁻³	± 5%
m	7.5 kg	± 4%

Fig. 1.1**(i)** Calculate the diameter d .

$d = \dots\dots\dots$ m [1]

(ii) Use your answer in **(i)** and the data in Fig. 1.1 to determine the value of d , with its absolute uncertainty, to an appropriate number of significant figures.

$d = \dots\dots\dots \pm \dots\dots\dots$ m [3]

[Total: 5]

63. 9702_w16_qp_22 Q: 1

(a) (i) Define *pressure*.

.....

.....[1]

(ii) Show that the SI base units of pressure are $\text{kg m}^{-1} \text{s}^{-2}$.

[1]

(b) Gas flows through the narrow end (nozzle) of a pipe. Under certain conditions, the mass m of gas that flows through the nozzle in a short time t is given by

$$\frac{m}{t} = kC\sqrt{\rho P}$$

where k is a constant with no units,
 C is a quantity that depends on the nozzle size,
 ρ is the density of the gas arriving at the nozzle,
 P is the pressure of the gas arriving at the nozzle.

Determine the base units of C .

base units[3]

[Total: 5]

64. 9702_w16_qp_23 Q: 1

(a) Define *density*.

.....

.....[1]

(b) The mass m of a metal sphere is given by the expression

$$m = \frac{\pi d^3 \rho}{6}$$

where ρ is the density of the metal and d is the diameter of the sphere.

Data for the density and the mass are given in Fig. 1.1.

quantity	value	uncertainty
ρ	8100 kg m ⁻³	± 5%
m	7.5 kg	± 4%

Fig. 1.1**(i)** Calculate the diameter d .

$d =$ m [1]

(ii) Use your answer in **(i)** and the data in Fig. 1.1 to determine the value of d , with its absolute uncertainty, to an appropriate number of significant figures.

$d =$ ± m [3]

[Total: 5]

65. 9702_s15_qp_22 Q: 4

- (a) A gas molecule has a mass of $6.64 \times 10^{-27} \text{ kg}$ and a speed of 1250 m s^{-1} . The molecule collides normally with a flat surface and rebounds with the same speed, as shown in Fig. 4.1.

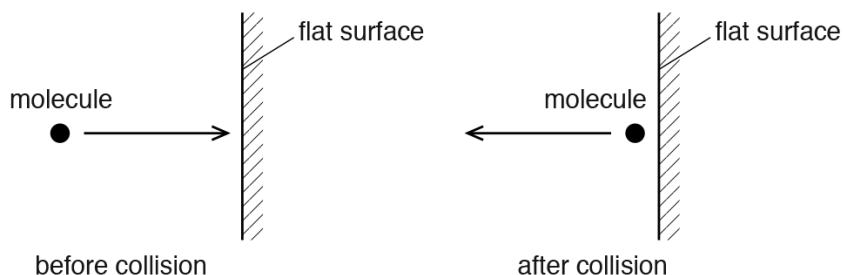


Fig. 4.1

Calculate the change in momentum of the molecule.

change in momentum = ... N s [2]

- (b) (i) Use the kinetic model to explain the pressure exerted by gases.

.....

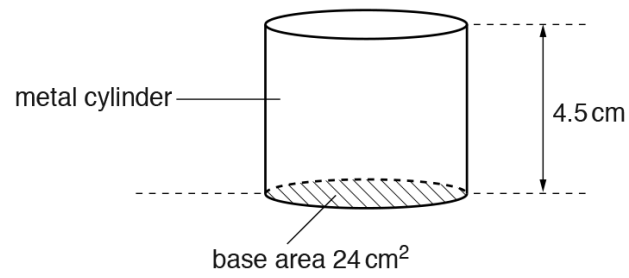
 [3]

- (ii) Explain the effect of an increase in density, at constant temperature, on the pressure of a gas.

.....
 [1]

66. 9702_w15_qp_21 Q: 4

Fig. 4.1 shows a metal cylinder of height 4.5 cm and base area 24 cm^2 .

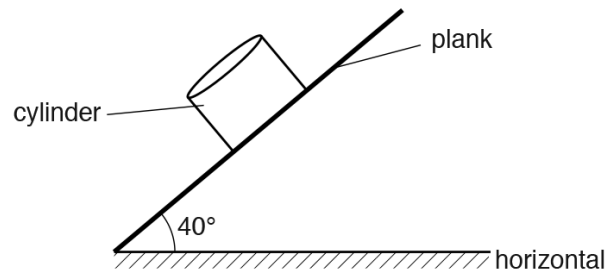
**Fig. 4.1**

The density of the metal is 7900 kg m^{-3} .

(a) Show that the mass of the cylinder is 0.85 kg.

[2]

(b) The cylinder is placed on a plank, as shown in Fig. 4.2.

**Fig. 4.2**

The plank is at an angle of 40° to the horizontal.

Calculate the pressure on the plank due to the cylinder.

pressure = ... Pa [3]

- (c) The cylinder then slides down the plank with a constant acceleration of 3.8 ms^{-2} .
A constant frictional force f acts on the cylinder.

Calculate the frictional force f .

$f =$ N [3]

67. 9702_w15_qp_23 Q: 7

A steel wire of cross-sectional area 15 mm^2 has an ultimate tensile stress of $4.5 \times 10^8\text{ N m}^{-2}$.

(a) Calculate the maximum tension that can be applied to the wire.

tension = ... N [2]

(b) The steel of the wire has density 7800 kg m^{-3} . The wire is hung vertically.

Calculate the maximum length of the steel wire that could be hung vertically before the wire breaks under its own weight.

length = ... m [3]

43. 9702_s18_qp_21 Q: 3

	Answer	Mark
(a)	mass is the property (of a body/object) resisting changes in motion or mass is the quantity of matter (in a body)	B1
(b)(i)	force on A (by B) equal <u>and opposite</u> to force on B (by A) or both A and B exert equal and opposite forces on each other	B1
	force is rate of change of momentum <u>and</u> time (of contact) is same	B1
(b)(ii)	$p = mv$ or $3M \times 0.40$ or $M \times 0.25$ or $3M \times 0.2$ or Mv	C1
	$(3M \times 0.40) - (M \times 0.25) = (3M \times 0.2) + Mv$	C1
	$v = (3 \times 0.40) - 0.25 - (3 \times 0.2)$ $= 0.35 \text{ m s}^{-1}$	A1
(b)(iii)	1. relative speed of approach $= 0.40 + 0.25$ $= 0.65 \text{ m s}^{-1}$	A1
	2. relative speed of separation $= 0.35 - 0.20$ $= 0.15 \text{ m s}^{-1}$	A1
(b)(iv)	(relative) speed of separation not equal to/less than (relative) speed of approach or answers (to (b)(iii) are) not equal and so inelastic collision	B1

44. 9702_m17_qp_22 Q: 1

	Answer	Mark
(a)	scalars: kinetic energy, power, work	A1
	vectors: acceleration, force, momentum	A1
(b)(i)	mass = volume $\times$ density or $m = V \times \rho$ $= 4/3 \pi (23 \times 10^{-2})^3 \times 82$	C1
	weight $= 4/3 \pi (23 \times 10^{-2})^3 \times 82 \times 9.8 = 41 \text{ N}$	A1
(b)(ii)	vertical component of tension $= 290 \sin 75^\circ$ or $290 \cos 15^\circ (= 280)$	C1
	upthrust $= 290 \sin 75^\circ + 41$ $= 320 (321) \text{ N}$	A1
(b)(iii)	the water pressure is greater than the air pressure or the pressure on lower surface (of sphere) is greater than the pressure on upper surface (of sphere)	B1

45. 9702_s16_qp_21 Q: 3

- (a) (i) force ($= mg = 0.15 \times 9.81 = 1.5$ (1.47) N) A1 [1]
- (ii) resultant force (on ball) is zero so normal contact force = weight
 or
 the forces are in opposite directions so normal contact force = weight
 or
 normal contact force up = weight down A1 [1]
- (b) (i) (resultant) force proportional/equal to rate of change of momentum B1 [1]
- (ii) change in momentum $= 0.15 \times (6.2 + 2.5) (= 1.305 \text{ N s})$ C1
- magnitude of force $= 1.305 / 0.12$
 $= 11$ (10.9) N A1
- or
- (average) acceleration $= (6.2 + 2.5) / 0.12 (= 72.5 \text{ m s}^{-2})$ (C1)
- magnitude of force $= 0.15 \times 72.5$
 $= 11$ (10.9) N (A1)
- (direction of force is) upwards/up B1 [3]
- (iii) there is a change/gain in momentum of the floor M1
- this is equal (and opposite) to the change/loss in momentum of the ball so momentum is conserved A1 [2]
- or
- change of (total) momentum of ball and floor is zero (M1)
 so momentum is conserved (A1)
- or
- (total) momentum of ball and floor before is equal to the (total) momentum of ball and floor after (M1)
 so momentum is conserved (A1)

46. 9702_w19_qp_22 Q: 4

	Answer	Mark
(a)(i)	(vertically) upwards/up	B1
(a)(ii)	increases (with time/velocity/depth)	B1
(b)(i)	for a body in (rotational) equilibrium	B1
	sum/total of clockwise moments about a point = sum/total of anticlockwise moments about the (same) point	B1
(b)(ii)	$(F_B \times 5.0)$ or (380×2.5) or (750×1.6)	C1
	$(F_B \times 5.0) = (380 \times 2.5) + (750 \times 1.6)$	A1
	$F_B = 430 \text{ N}$	
(b)(iii)	taking moments about C:	C1
	$(380 \times 2.5) = 750 \times (2.0 - x)$	
	$(2.0 - x) = 1.3$	A1
	$x = 0.7 \text{ m}$	
	or	
	moments may be taken about other points, e.g. about D:	(C1)
	$(380 \times 4.5) + (750 \times x) = 1130 \times 2.0$	
	$x = 0.7 \text{ m}$	(A1)

47. 9702_w19_qp_23 Q: 1

	Answer	Mark
(a)	base units: $\text{kg m s}^{-2} \times \text{m}$ $= \text{kg m}^2 \text{s}^{-2}$	A1
(b)(i)	distance of COG from P (= GP) $= 17 \cos 45^\circ - 4.0$ or $(144.5)^{1/2} - 4.0$ (= 8.0 cm)	C1
	moment = $0.15 \times 8.0 \times 10^{-2}$ $= 1.2 \times 10^{-2} \text{ N m}$	A1
(b)(ii)	(line of action of) weight acts through pivot/P or distance between (line of action of) weight and pivot/P is zero	B1
	(so) weight does not have a moment about pivot/P	B1

48. 9702_w17_qp_22 Q: 2

	Answer	Mark
(a)	force $\times$ <u>perpendicular</u> distance (of line of action of force) to/from a point	B1
(b)(i)	$2.4r$ or $(1.2 \times 2r)$ or $(1.2r + 1.2r)$	A1
(b)(ii)	(anticlockwise moment =) $6.0 \times r/2 \times \sin \theta$	C1
	$6.0 \times r/2 \times \sin \theta = 2.4r$	A1
	$\theta = 53^\circ$	
(b)(iii)	6.0 N	A1

49. 9702_s20_qp_23 Q: 2

	Answer	Mark
(a)	a body continues at (rest or) constant velocity unless acted upon by a resultant force	B1
(b)(i)	distance = $[\frac{1}{2} \times (2.0 + 4.4) \times 3.0] + [4.4 \times 2.0]$	C1
	= 9.6 + 8.8	A1
	= 18 m	
(b)(ii)	$a = (v - u) / t$ or gradient or $\Delta v / (\Delta) t$	C1
	e.g. $a = (4.4 - 2.0) / 3.0 = 0.80 \text{ m s}^{-2}$	A1
(b)(iii)	1. force = $240 \cos 28^\circ$ or $240 \sin 62^\circ$	A1
	= 210 N	
	2. resultant force = 89×0.80 (= 71.2 N)	C1
	$R = 210 - 71$	A1
(b)(iv)	$T \sin 45^\circ = mg$	C1
	$T = (89 \times 9.81) / \sin 45^\circ$	A1
	= 1200 N	

50. 9702_w20_qp_22 Q: 4

	Answer	Mark
(a)	(component =) $96 \sin 38^\circ = 59 \text{ (N)}$ or $96 \cos 52^\circ = 59 \text{ (N)}$	A1
(b)	(45×2.9) or $(T \times 1.8)$ or (59×1.5)	C1
	$(45 \times 2.9) = (T \times 1.8) + (59 \times 1.5)$	C1
	$T = 23 \text{ N}$	A1

51. 9702_w20_qp_23 Q: 2

	Answer	Mark
(a)	point where (all) the weight (of the body)	M1
	is considered/seems to act	A1
(b)(i)	horizontal component of force = $38 \cos 60^\circ$ or $38 \sin 30^\circ$ = 19 N	A1
(b)(ii)	$(T \times 1.2)$ or (19×0.9) or 17	C1
	$(T \times 1.2) = (19 \times 0.9)$	A1
	$T = 14 \text{ N}$	
(b)(iii)	$F = 45 + 38 \sin 60^\circ$ = 78 N	A1

52. 9702_w18_qp_22 Q: 2

	Answer	Mark
(a)	ampere kelvin (allow mole, candela) any two correct answers, 1 mark each	B2
(b)(i)	frictional (force)/friction	B1
(b)(ii)	$W \cos 31^\circ \times 3.0$ or 90×6.0	C1
	$W \cos 31^\circ \times 3.0 = 90 \times 6.0$	A1
	$W = 210 \text{ N}$	
(b)(iii)	$X = 90 \sin 31^\circ$ $= 46 \text{ N}$	A1

53. 9702_s15_qp_22 Q: 3

- (a) (i) (vertical component = $44 \sin 30^\circ =$) 22 N A1 [1]
(ii) (horizontal component = $44 \cos 30^\circ =$) 38(.1) N A1 [1]
- (b) $W \times 0.64 = 22 \times 1.60$ C1
 $(W =)$ 55 N A1 [2]
- (c) F has a horizontal component (not balanced by W)
or F has 38 N acting horizontally
or 38 N acts on wall
or vertical component of F does not balance W
or F and W do not make a closed triangle of forces B1 [1]
- (d) line from P in direction towards point on wire vertically above W and direction up B1 [1]

54. 9702_w15_qp_22 Q: 4

- (a) product of the force and the perpendicular distance to/from a point/pivot B1 [1]
- (b) (i) $4000 \times 2.8 \times \sin 30^\circ$ or $500 \times 1.4 \times \sin 30^\circ$ or $T \times 2.8$
or 4000×1.4 or 500×0.7 B1
 $4000 \times 2.8 \times \sin 30^\circ + 500 \times 1.4 \times \sin 30^\circ = T \times 2.8$ M1
hence $T = 2100$ (2125) N A0 [2]
- (ii) ($T_v = 2100 \cos 60^\circ =$) 1100 (1050) N A1 [1]
- (iii) there is an upward (vertical component of) force at A B1
upward force at A + $T_v =$ sum of downward forces/weight/load/4500 N B1 [2]

55. 9702_w20_qp_21 Q: 1

	Answer	Mark
(a)(i)	force $\times$ <u>perpendicular</u> distance (of line of action of force to the point)	B1
(a)(ii)	units: $\text{kg m s}^{-2} \text{ m}$ $= \text{kg m}^2 \text{ s}^{-2}$	A1
(b)	$W = \rho Vg$ or $W = \rho ALg$	C1
	$A = 5.2 / (790 \times 2.4 \times 9.81)$ $(= 2.8 \times 10^{-4} \text{ (m}^2\text{)})$	C1
	$= 2.8 \times 10^2 \text{ mm}^2$	A1
(c)(i)	(component $=$) $5.2 \sin 56^\circ = 4.3 \text{ (N)}$ or $5.2 \cos 34^\circ = 4.3 \text{ (N)}$	A1
(c)(ii)	$(T \times 2.4)$ or (4.3×1.2) or (4.6×1.8)	C1
	$(T \times 2.4) + (4.3 \times 1.2) = (4.6 \times 1.8)$	C1
	$T = 1.3 \text{ N}$	A1

56. 9702_w20_qp_22 Q: 2

	Answer	Mark
(a)(i)	$(\Delta)p = \rho g(\Delta)h$	C1
	$520 = 1000 \times 9.81 \times h$	
	$h = 0.053 \text{ m}$	A1
(a)(ii)	(upthrust $=$) $(\Delta)p \times A$	C1
	$= (\Delta)p \times \pi(d/2)^2$ or $(\Delta)p \times \pi r^2$	
	$= 520 \times \pi(0.031/2)^2 = 0.39 \text{ (N)}$	A1
(a)(iii)	$T = 0.84 - 0.39$ $= 0.45 \text{ N}$	A1

	Answer	Mark
(b)(i)	$a = (v - u) / t$ or $(\Delta)v / (\Delta)t$ or gradient	C1
	$= \text{e.g. } 8.0 \times 10^{-2} / 2.0$	A1
	$= 4.0 \times 10^{-2} \text{ m s}^{-2}$	
(b)(ii)	distance $= (\frac{1}{2} \times 2.5 \times 0.10) + (\frac{1}{2} \times 1.5 \times 0.10)$ or $(\frac{1}{2} \times 4.0 \times 0.10)$ $(= 0.20 \text{ (m)})$	C1
	depth $= 0.32 - 0.20$	A1
	$= 0.12 \text{ m}$	
(c)(i)	viscous (force)	B1
(c)(ii)	viscous force increases (with speed/time/depth)	B1
	(so) acceleration decreases	B1

57. 9702_w18_qp_22 Q: 3

	Answer	Mark
(a)	<u>sum/total</u> momentum (of a system of bodies) is constant or <u>sum/total</u> momentum before = <u>sum/total</u> momentum after	M1
	for an isolated system or no (resultant) external force	A1
(b)(i)	$m = \rho V$	C1
	$= 1.3 \times \pi \times 0.045^2 \times 1.8 \times 2.0 = 0.030 \text{ (kg)}$	A1
(b)(ii)	1. $(\Delta)p = (\Delta)mv$	C1
	$= 0.030 \times 1.8$	A1
	$= 0.054 \text{ N s}$	
	2. $F = 0.054/2.0$ or $0.030 \times 1.8/2.0$	A1
(b)(iii)	$= 0.027 \text{ N}$	
	force on air (by propeller) equal to force on propeller (by air)	M1
(b)(iv)	and opposite (in direction)	A1
	resultant force $= 0.20 \times 0.075 (= 0.015 \text{ N})$	C1
(b)(iv)	frictional force $= 0.027 - 0.015$	
	$= 0.012 \text{ N}$	A1

58. 9702_w18_qp_23 Q: 3

	Answer	Mark
(a)	(resultant) force proportional/equal to rate of change of momentum	B1
(b)(i)	$\rho = m/V$	C1
	$V = \pi \times (7.5 \times 10^{-3})^2 \times 13 \times 0.2 (= 4.59 \times 10^{-4} \text{ m}^3)$	A1
	$m = \pi \times (7.5 \times 10^{-3})^2 \times 13 \times 0.2 \times 1000 = 0.46 \text{ kg}$	
(b)(ii)	1. $(\Delta)p = (\Delta m)v$	C1
	$(\Delta)p = 0.46 \times 13$	A1
	$= 6.0 \text{ N s}$	
	2. $F = 6.0/0.20$	A1
(b)(iii)	$= 30 \text{ N}$	
	force on water (by rocket/nozzle) equal to force on rocket/nozzle (by water)	M1
(b)(iv)	in the opposite direction	A1
	1. mass $= 0.40 + 0.70 - 0.46 = 0.64 \text{ kg}$	A1
	2. acceleration $= [30 - (0.64 \times 9.81)]/0.64$ or $30/0.64 - 9.81$	C1
	$= 37 \text{ ms}^{-2}$	A1

59. 9702_s17_qp_21 Q: 3

	Answer	Mark
(a)	$\rho = m / V$	C1
	$V = \pi d^2 L / 4$ or $\pi r^2 L$	C1
	weight = $2.7 \times 10^3 \times \pi (1.2 \times 10^{-2})^2 \times 5.0 \times 10^{-2} \times 9.81 = 0.60 \text{ N}$	A1
(b)(i)	the point from where (all) the weight (of a body) seems to act	B1
(b)(ii)	$W \times 12$	C1
	$(0.25 \times 8) + (0.6 \times 38)$	C1
	$W = (2 + 22.8) / 12$ $= 2.1 (2.07) \text{ N}$	A1
(c)(i)	pressure changes with depth (in water) or pressure on bottom (of cylinder) different from pressure on top	B1
	pressure on bottom of cylinder <u>greater than</u> pressure on top or force (up) on bottom of cylinder <u>greater than</u> force (down) on top	B1
(c)(ii)	anticlockwise moment reduced and reducing the weight of X reduces clockwise moment or anticlockwise moment reduced so clockwise moment now greater than (total) anticlockwise moment	B1

60. 9702_s16_qp_22 Q: 2

- (a) $p = F / A$ M1
- use of $m = \rho V$ and use of $V = Ah$ and use of $F = mg$ M1
- correct substitution to obtain $p = \rho gh$ A1 [3]
- (b) (i) (when h is zero the pressure is not zero due to) pressure from the air/atmosphere B1 [1]
- (ii) gradient = ρg or $P - 1.0 \times 10^5 = \rho gh$ C1
- e.g. $\rho g = 1.0 \times 10^5 / 0.75 (= 133333)$
- $\rho = 133333 / 9.81$
- $= 14000 (13592) \text{ kg m}^{-3}$ A1 [2]

61. 9702_s16_qp_23 Q: 4

(a) (resultant force = 0) (equilibrium)

therefore: weight – upthrust = force from thin wire (allow tension in wire)

or

$$5.3 \text{ (N)} - \text{upthrust} = 4.8 \text{ (N)}$$

B1 [1]

(b) difference in weight = upthrust or upthrust = 0.5 (N)

$$0.5 = \rho ghA \text{ or } m = 0.5/9.81 \text{ and } V = 5.0 \times 13 \times 10^{-6} \text{ (m}^3\text{)}$$

C1

$$\rho = 0.5 / (9.81 \times 5.0 \times 13 \times 10^{-6})$$

C1

$$= 780 \text{ (784) kg m}^{-3}$$

A1 [3]

62. 9702_w16_qp_21 Q: 1

(a) (density =) mass / volume

B1 [1]

(b) (i) $d = [(6 \times 7.5) / (\pi \times 8100)]^{1/3}$

$$= 0.12(1) \text{ m}$$

A1 [1]

(ii) percentage uncertainty = $(4 + 5) / 3$ (= 3%)

or

fractional uncertainty = $(0.04 + 0.05) / 3$ (= 0.03)

C1

absolute uncertainty = $0.03 \times 0.121 = 0.0036$

C1

$$d = 0.121 \pm 0.004 \text{ m}$$

A1 [3]

63. 9702_w16_qp_22 Q: 1

(a) (i) force / area (normal to the force)

B1 [1]

(ii) ($p = F/A$ so) units: $\text{kg ms}^{-2} / \text{m}^2 = \text{kg m}^{-1} \text{s}^{-2}$

A1 [1]

allow use of other correct equations:

e.g. ($\Delta p = \rho g \Delta h$ so) $\text{kg m}^{-3} \text{ms}^{-2} \text{m} = \text{kg m}^{-1} \text{s}^{-2}$ e.g. ($p = W/\Delta V$ so) $\text{kg ms}^{-2} \text{m} / \text{m}^3 = \text{kg m}^{-1} \text{s}^{-2}$ **(b)** units for m : kg, t : s and ρ : kg m^{-3}

C1

units of C: $\text{kg/s} (\text{kg m}^{-3} \text{kg m}^{-1} \text{s}^{-2})^{1/2}$

or

units of C²: $\text{kg}^2 / \text{s}^2 \text{kg m}^{-3} \text{kg m}^{-1} \text{s}^{-2}$

C1

units of C: m^2

A1 [3]

64. 9702_w16_qp_23 Q: 1

- (a) (density =) mass/volume B1 [1]
- (b) (i) $d = [(6 \times 7.5)/(\pi \times 8100)]^{1/3}$
 $= 0.12(1) \text{ m}$ A1 [1]
- (ii) percentage uncertainty = $(4 + 5)/3$ (= 3%)
 or
 fractional uncertainty = $(0.04 + 0.05)/3$ (= 0.03) C1
 absolute uncertainty = $0.03 \times 0.121 = 0.0036$ C1
 $d = 0.121 \pm 0.004 \text{ m}$ A1 [3]

65. 9702_s15_qp_22 Q: 4

- (a) ($p =$) mv C1
 $\Delta p (= -6.64 \times 10^{-27} \times 1250 - 6.64 \times 10^{-27} \times 1250) = 1.66 \times 10^{-23} \text{ N s}$ A1 [2]
- (b) (i) molecule collides with wall/container **and** there is a change in momentum B1
 change in momentum / time is force or $\Delta p = Ft$ B1
many/all/sum of molecular collisions over surface/area of container produces pressure B1 [3]
- (ii) more collisions per unit time so greater pressure B1 [1]

66. 9702_w15_qp_21 Q: 4

- (a) density = mass/volume C1
 $\text{mass} = 7900 \times 4.5 \times 24 \times 10^{-6} = 0.85 (0.853) \text{ kg}$ M1 [2]
- (b) pressure = force/area C1
 $\text{force} = W \cos 40^\circ$ C1
 $\text{pressure} = (0.85 \times 9.81 \cos 40^\circ)/24 \times 10^{-4}$
 $= 2.7 (2.66) \times 10^3 \text{ Pa}$ A1 [3]
- (c) $F = ma$ C1
 $W \sin 40^\circ - f = ma$ C1
 $0.85 \times 9.81 \times \sin 40^\circ - f = 0.85 \times 3.8$
 $f (= 5.36 - 3.23) = 2.1 \text{ N}$ [5.38 – 3.242 if 0.8532 kg is used for the mass] A1 [3]

67. 9702_w15_qp_23 Q: 7

(a) stress or $\sigma = F/A$

C1

$$\text{max. tension} = \text{UTS} \times A = 4.5 \times 10^8 \times 15 \times 10^{-6} = 6800 \text{ (6750) N}$$

A1 [2]

(b) $\rho = m/V$

C1

$$\text{weight} = mg = \rho Vg = \rho ALg$$

$$6750 = 7.8 \times 10^3 \times 15 \times 10^{-6} \times L \times 9.81$$

C1

$$L = 5.9 \text{ (5.88)} \times 10^3 \text{ m}$$

A1

or

$$\text{maximum mass} = 6750/9.81 = 688 \text{ kg}$$

(C1)

$$\text{mass per unit length} = \rho A = 0.117 \text{ kg m}^{-1}$$

(C1)

$$L = 688/0.117 = 5.9 \times 10^3 \text{ m}$$

(A1)

or

$$\text{maximum mass} = 6750/9.81 = 688 \text{ kg}$$

(C1)

$$\text{volume} = m/\rho = 0.0882 \text{ m}^3 = LA$$

(C1)

$$L = 0.0882/15 \times 10^{-6} = 5.9 \times 10^3 \text{ m}$$

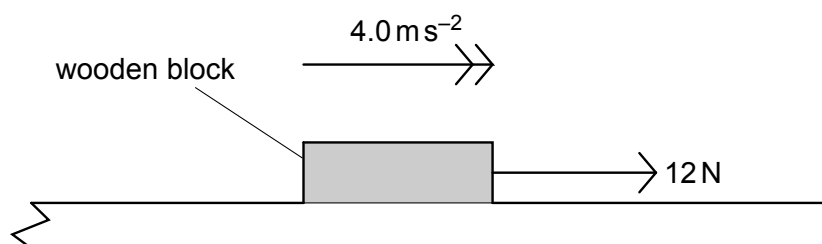
(A1) [3]

68. 9702_s20_qp_21 Q: 2

	Answer	Mark
(a)	(resultant) force proportional to rate of change of momentum	B1
(b)(i)	arrow drawn vertically downwards from point X	B1
(b)(ii)	$s = ut + \frac{1}{2}at^2$ $h = \frac{1}{2} \times 9.81 \times 0.81^2$	C1
	= 3.2 m	A1
(b)(iii)	$d = 5.4 \times 0.81$	A1
	= 4.4 m	
(c)(i)	downward pointing arrow labelled weight	B1
	upward pointing arrow labelled air resistance	B1
(c)(ii)	air resistance increases	B1
	weight constant or <u>resultant</u> force decreases	B1
	(so) acceleration decreases	B1
(c)(iii)	gravitational potential energy to thermal/internal energy	B1

- 1 A wooden block of mass 0.60 kg is on a rough horizontal surface. A force of 12 N is applied to the block and it accelerates at 4.0 m s^{-2} .

9702/1/M/J/02/Q10



What is the magnitude of the frictional force acting on the block?

- A 2.4 N
- B 9.6 N
- C 14 N
- D 16 N

- 2 A submarine descends vertically at constant velocity. The three forces acting on the submarine are viscous drag, upthrust and weight.

9702/1/M/J/02/Q12

Which relationship between their magnitudes is correct?

- A weight < drag
- B weight = drag
- C weight < upthrust
- D weight > upthrust

- 3 A cylindrical block of wood has a cross-sectional area A and weight W . It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively.

9702/1/M/J/02/Q14

Which of the following expressions is equal to the upthrust on the block?

- A $(p_b - p_t)A + W$
- B $(p_b - p_t)$
- C $(p_b - p_t)A$
- D $(p_b - p_t)A - W$

- 4 A horizontal force of 90 N is used to push a box across a horizontal floor. The frictional force on the box is 50 N .

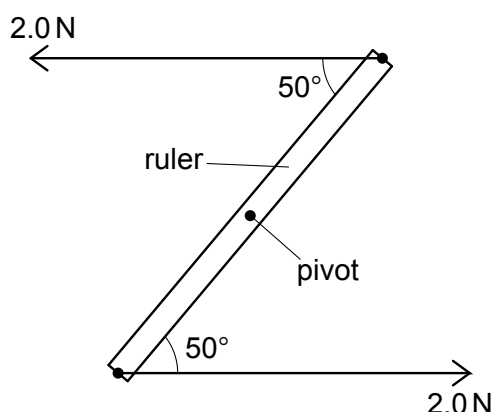
9702/01/O/N/04/Q16

What is the gain in kinetic energy of the box when it is moved through a distance of 6.0 m ?

- A 240 J
- B 300 J
- C 540 J
- D 840 J

- 5 A ruler of length 0.30 m is pivoted at its centre. Equal and opposite forces of magnitude 2.0 N are applied to the ends of the ruler, creating a couple as shown.

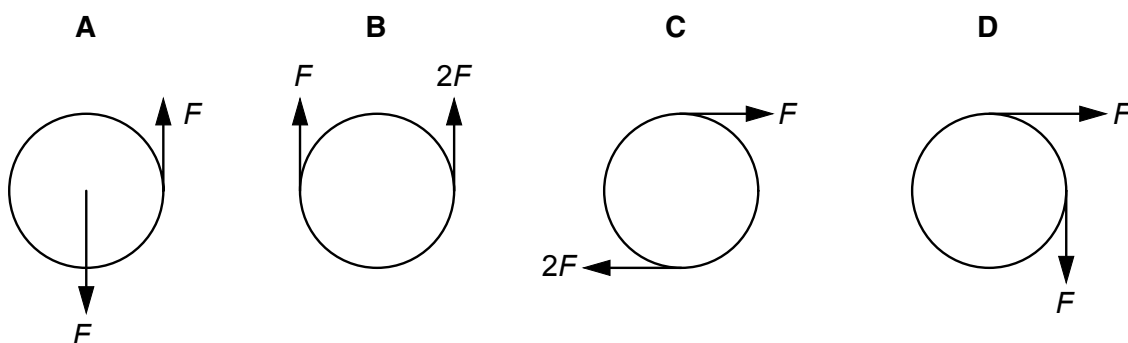
9702/1/M/J/02/Q13



What is the magnitude of the torque of the couple on the ruler when it is in the position shown?

- A 0.23 Nm B 0.39 Nm C 0.46 Nm D 0.60 Nm

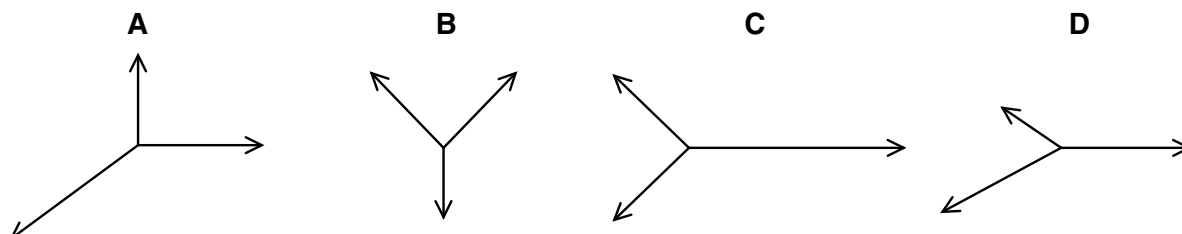
- 6 Which of the following pairs of forces, acting on a circular object, constitutes a couple? 9702/1/O/N/02/Q13



- 7 The diagrams represent systems of coplanar forces acting at a point. The lengths of the force vectors represent the magnitudes of the forces.

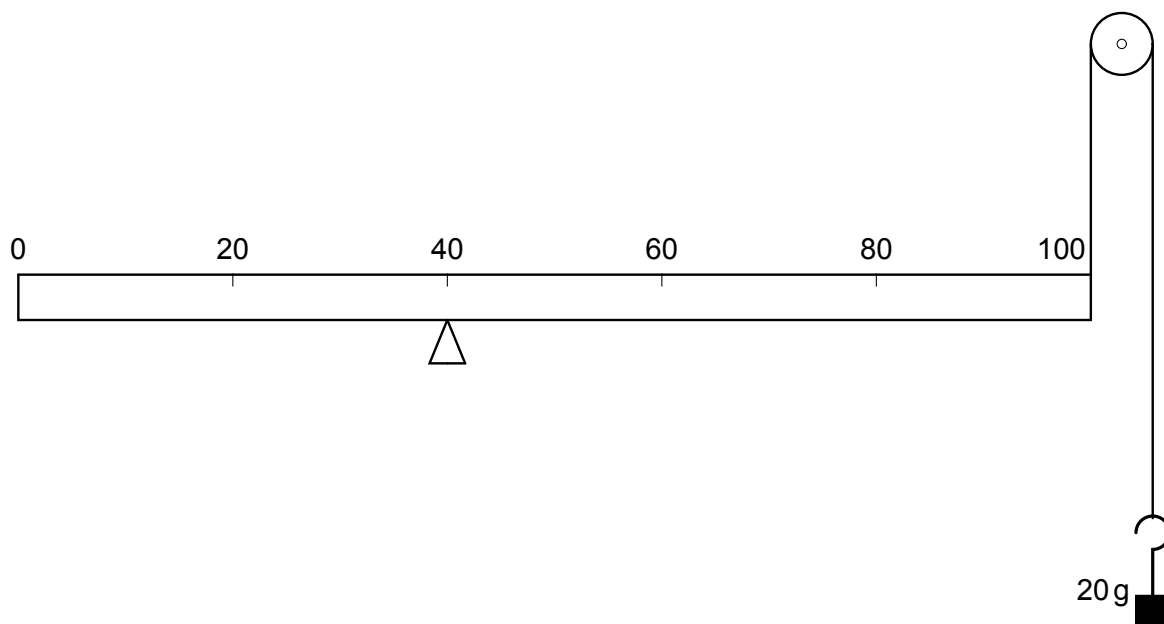
9702/1/O/N/02/Q15

Which system of forces is in equilibrium?



- 8 A uniform metre rule of mass 100 g is supported by a knife-edge at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram.

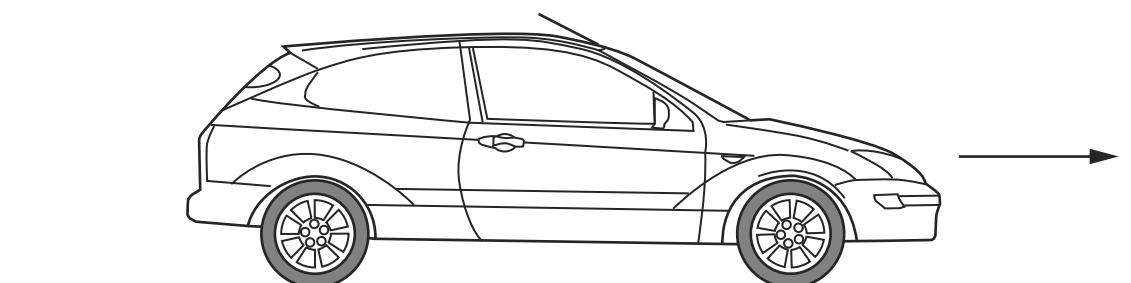
9702/1/O/N/02/Q14



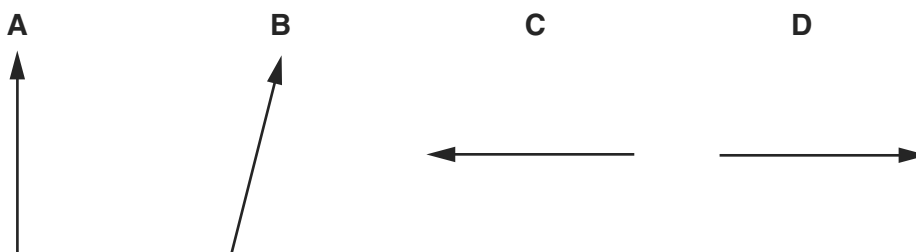
At which mark on the rule must a 50 g mass be suspended so that the rule balances?

- A 4 cm B 36 cm C 44 cm D 96 cm
- 9 A car with front-wheel drive accelerates in the direction shown.

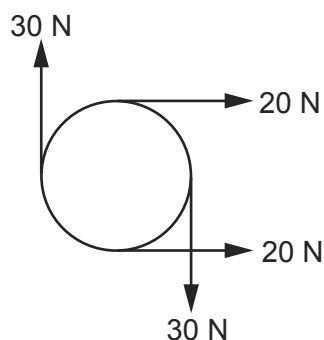
9702/01/M/J/03/Q11



Which diagram best shows the direction of the total force exerted by the road on the front wheels?



- 10 The diagram shows four forces applied to a circular object.

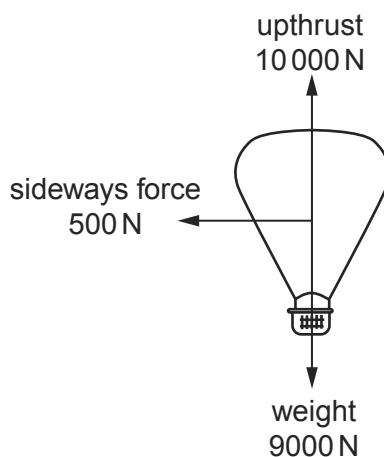


Which of the following describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
A	zero	zero
B	zero	non-zero
C	non-zero	zero
D	non-zero	non-zero

- 11 A balloon is acted upon by three forces, weight, upthrust and sideways force due to the wind, as shown in the diagram.

9702/01/M/J/03/Q14



What is the vertical component of the resultant force on the balloon?

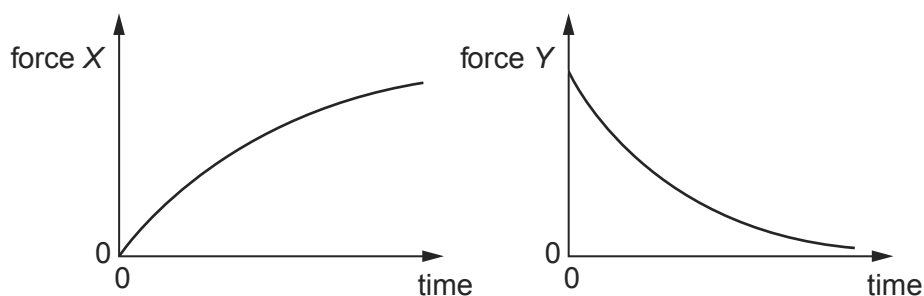
- A** 500 N **B** 1000 N **C** 10 000 N **D** 10 500 N
- 12 A steel sphere is dropped vertically onto a horizontal metal plate. The sphere hits the plate with a speed u , leaves it at a speed v , and rebounds vertically to half of its original height. 9702/11/M/J/11/Q14

Which expression gives the value of $\frac{v}{u}$?

- A** $\frac{1}{2^2}$ **B** $\frac{1}{2}$ **C** $\frac{1}{\sqrt{2}}$ **D** $1 - \frac{1}{\sqrt{2}}$

- 13 A ball falls from rest through air and eventually reaches a constant velocity.

For this fall, forces X and Y vary with time as shown.



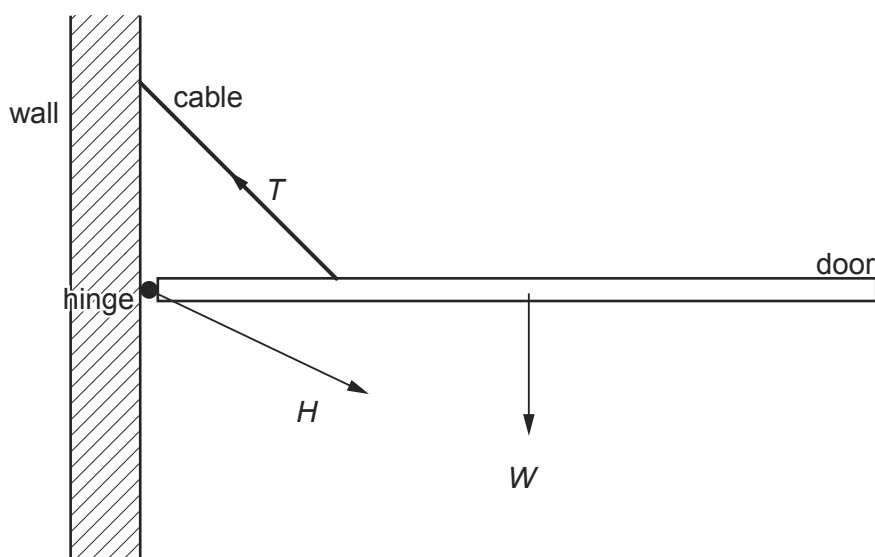
What are forces X and Y ?

	force X	force Y
A	air resistance	resultant force
B	air resistance	weight
C	upthrust	resultant force
D	upthrust	weight

- 14 A hinged door is held closed in the horizontal position by a cable.

Three forces act on the door: the weight W of the door, the tension T in the cable, and the force H at the hinge.

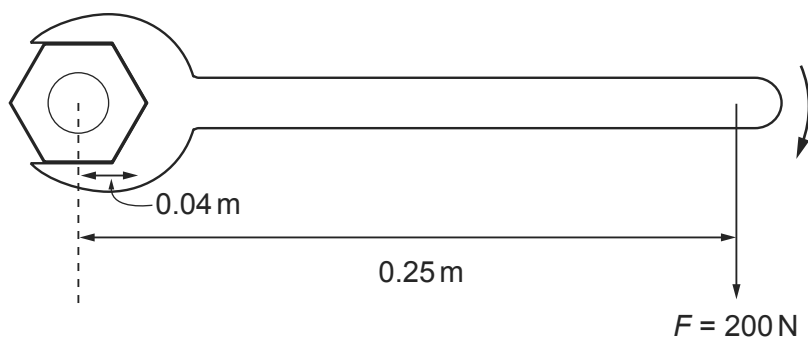
9702/01/O/N/03/Q16



Which list gives the three forces in **increasing** order of magnitude?

- A** H, T, W **B** T, H, W **C** W, H, T **D** W, T, H

- 15 A spanner is used to tighten a nut as shown.

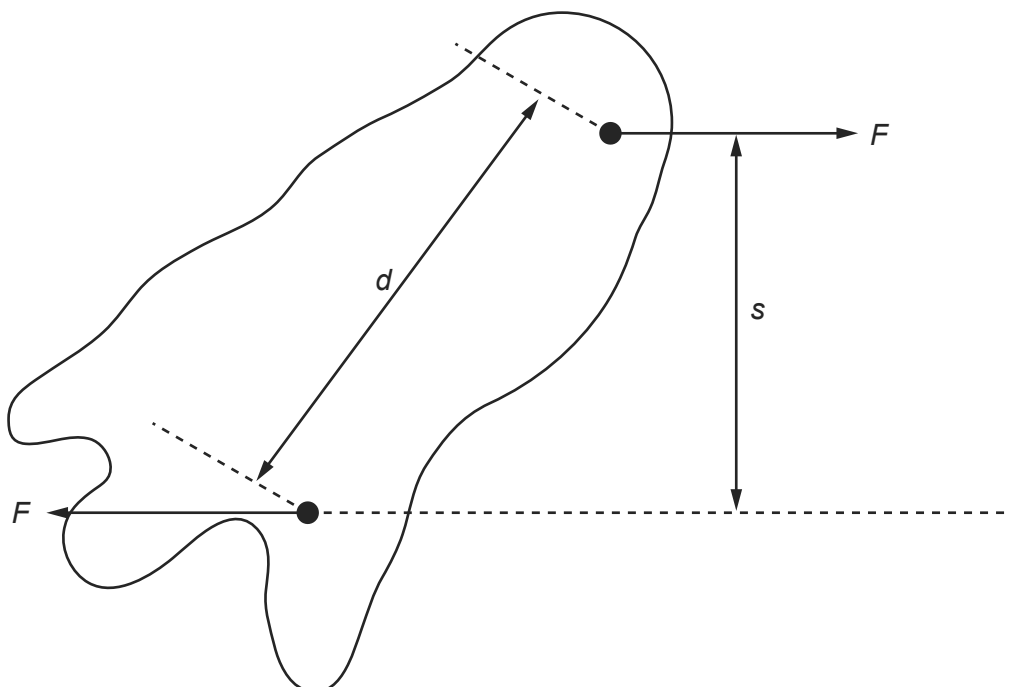


A force F is applied at right-angles to the spanner at a distance of 0.25 m from the centre of the nut. When the nut is fully tightened, the applied force is 200 N.

What is the resistive torque, in an anticlockwise direction, preventing further tightening?

- A 8 Nm
 - B 25 Nm
 - C 50 Nm
 - D 800 Nm
- 16 Two parallel forces, each of magnitude F , act on a body as shown.

9702/01/O/N/03/Q14



What is the magnitude of the torque on the body produced by these forces?

- A Fd
- B Fs
- C $2Fd$
- D $2Fs$

- 17 A force F is applied to a freely moving object. At one instant of time, the object has velocity v and acceleration a .

9702/01/O/N/03/Q15

Which quantities **must** be in the same direction?

- A a and v only
- B a and F only
- C v and F only
- D v , F and a

- 18 A ball falls vertically and bounces on the ground.

9702/01/M/J/04/Q10

The following statements are about the forces acting while the ball is in contact with the ground.

Which statement is correct?

- A The force that the ball exerts on the ground is always equal to the weight of the ball.
- B The force that the ball exerts on the ground is always equal in magnitude and opposite in direction to the force the ground exerts on the ball.
- C The force that the ball exerts on the ground is always less than the weight of the ball.
- D The weight of the ball is always equal in magnitude and opposite in direction to the force that the ground exerts on the ball.

- 19 An object, immersed in a liquid in a tank, experiences an upthrust.

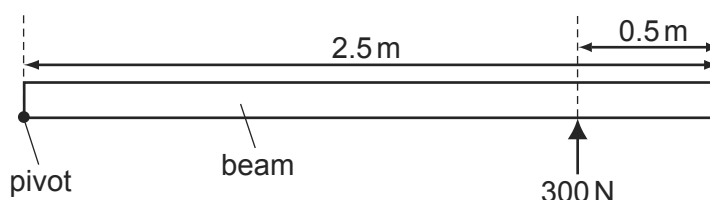
9702/01/M/J/04/Q12

What is the physical reason for this upthrust?

- A The density of the body differs from that of the liquid.
- B The density of the liquid increases with depth.
- C The pressure in the liquid increases with depth.
- D The value of g in the liquid increases with depth.

- 20 A long uniform beam is pivoted at one end. A force of 300 N is applied to hold the beam horizontally.

9702/01/O/N/04/Q13

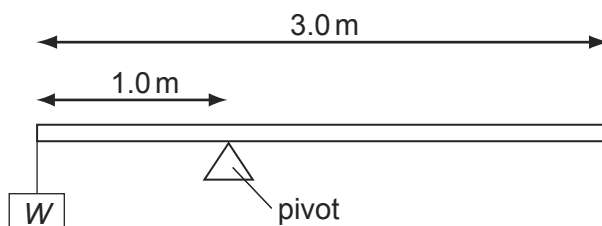


What is the weight of the beam?

- A 300 N
- B 480 N
- C 600 N
- D 960 N

- 21 A uniform beam of weight 50 N is 3.0 m long and is supported on a pivot situated 1.0 m from one end. When a load of weight W is hung from that end, the beam is in equilibrium, as shown in the diagram.

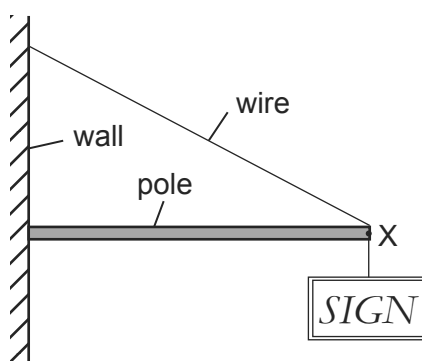
9702/01/M/J/04/Q13



What is the value of W ?

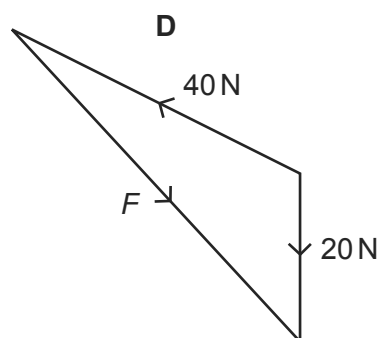
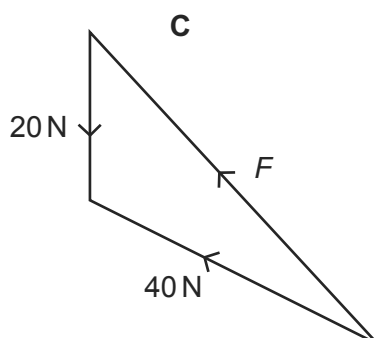
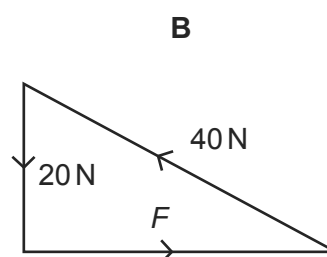
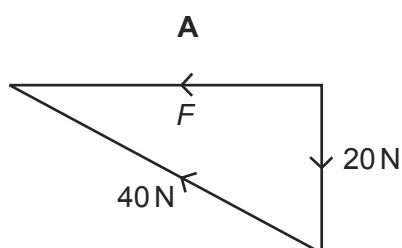
- A** 25 N **B** 50 N **C** 75 N **D** 100 N
- 22 The diagram shows a sign of weight 20 N suspended from a pole, attached to a wall. The pole is kept in equilibrium by a wire attached at point X of the pole.

9702/01/M/J/04/Q14



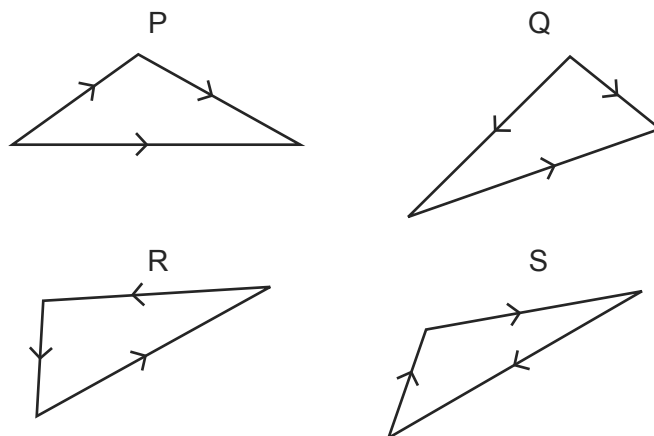
The force exerted by the pole at point X is F , and the tension in the wire is 40 N.

Which diagram represents the three forces acting at point X?



23 Which two vector diagrams represent forces in equilibrium?

9702/01/O/N/04/Q12



- A P and Q
- B Q and R
- C R and S
- D S and P

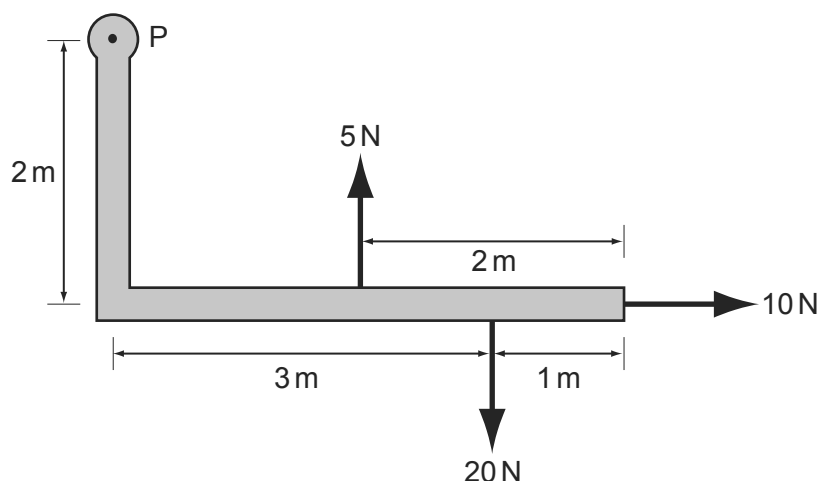
24 What is the centre of gravity of an object?

9702/01/M/J/05/Q12

- A the geometrical centre of the object
- B the point about which the total torque is zero
- C the point at which the weight of the object may be considered to act
- D the point through which gravity acts

25 An L-shaped rigid lever arm is pivoted at point P.

9702/01/M/J/05/Q13



Three forces act on the lever arm, as shown in the diagram.

What is the magnitude of the resultant moment of these forces about point P?

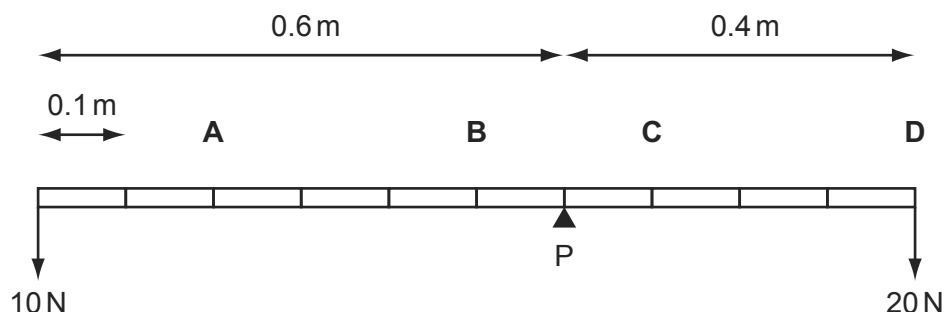
- A 30 Nm
- B 35 Nm
- C 50 Nm
- D 90 Nm

- 26 A uniform beam of weight 100 N is pivoted at P as shown. Weights of 10 N and 20 N are attached to its ends.

9702/01/O/N/05/Q12

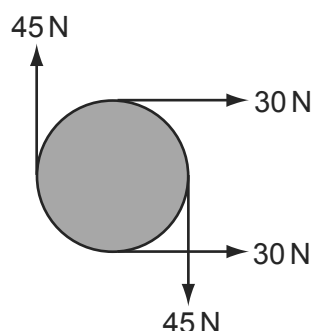
The length of the beam is marked off at 0.1 m intervals.

At which point should a further weight of 20 N be attached to achieve equilibrium?



- 27 The diagram shows four forces applied to a circular object.

9702/01/O/N/05/Q13



Which of the following describes the resultant force and resultant torque on the object?

9702/01/O/N/05

	resultant force	resultant torque
A	non-zero	non-zero
B	non-zero	zero
C	zero	non-zero
D	zero	zero

- 28 A cyclist is riding at a steady speed on a level road.

9702/01/M/J/06/Q10

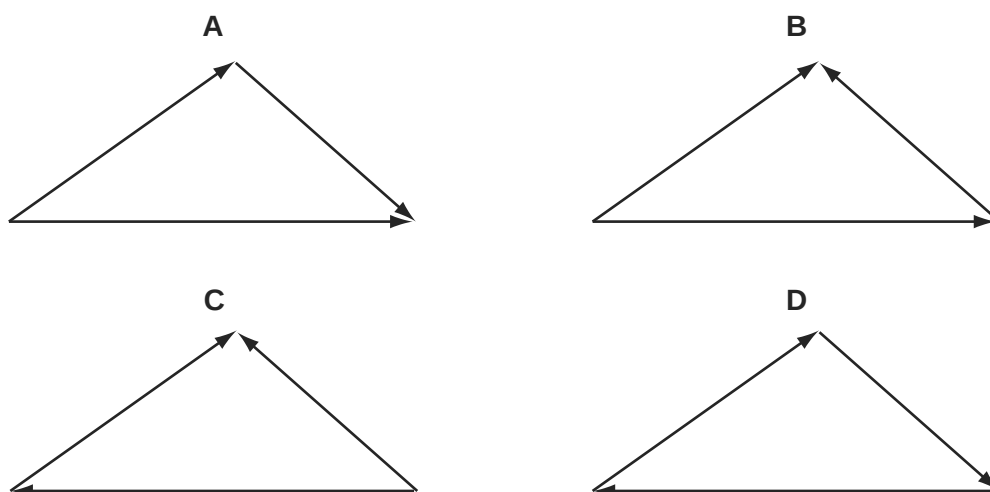
According to Newton's third law of motion, what is equal and opposite to the backward push of the back wheel on the road?

- A** the force exerted by the cyclist on the pedals
- B** the forward push of the road on the back wheel
- C** the tension in the cycle chain
- D** the total air resistance and friction force

- 29 The diagrams show three forces acting on a body.

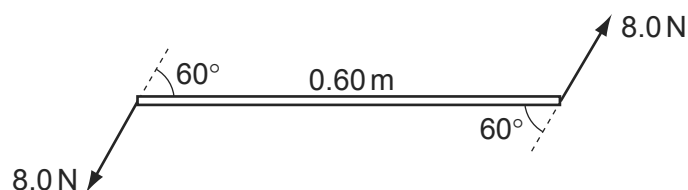
9702/01/M/J/06/Q13

In which diagram is the body in equilibrium?



- 30 Two 8.0 N forces act at each end of a beam of length 0.60 m. The forces are parallel and act in opposite directions. The angle between the forces and the beam is 60° .

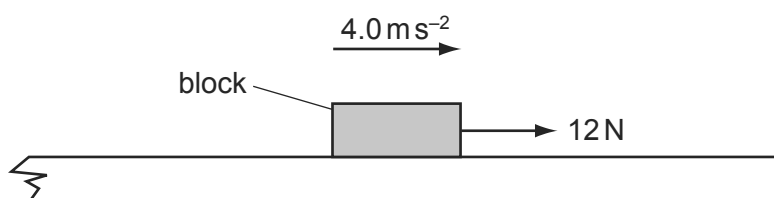
9702/01/M/J/07/Q13



What is the torque of the couple exerted on the beam?

- A** 2.4 Nm **B** 4.2 Nm **C** 4.8 Nm **D** 9.6 Nm
- 31 A block of mass 0.60 kg is on a rough horizontal surface. A force of 12 N is applied to the block and it accelerates at 4.0 m s^{-2} .

9702/01/O/N/07/Q10

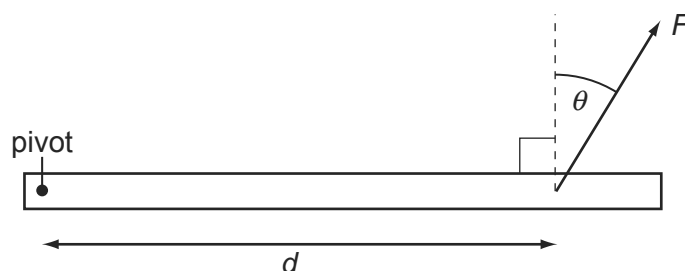


What is the magnitude of the frictional force acting on the block?

- A** 2.4 N **B** 5.3 N **C** 6.7 N **D** 9.6 N

- 32 A force F is applied to a beam at a distance d from a pivot. The force acts at an angle θ to a line perpendicular to the beam.

9702/01/M/J/06/Q14

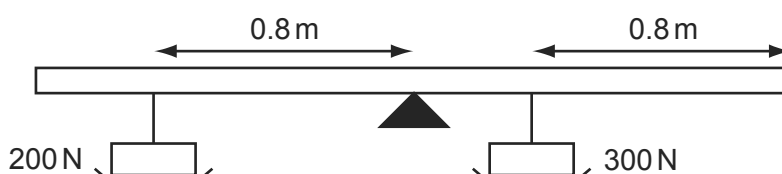


Which combination will cause the largest turning effect about the pivot?

	F	d	θ
A	large	large	large
B	large	large	small
C	small	small	large
D	small	large	small

- 33 A rigid uniform bar of length 2.4 m is pivoted horizontally at its mid-point.

9702/01/M/J/06/Q15



Weights are hung from two points of the bar as shown in the diagram. To maintain horizontal equilibrium, a couple is applied to the bar.

What is the torque and direction of this couple?

- A** 40 N m clockwise
B 40 N m anticlockwise
C 80 N m clockwise
D 80 N m anticlockwise
- 34 A ball is falling at terminal speed in still air. The forces acting on the ball are upthrust, viscous drag and weight.

9702/01/M/J/08/Q12

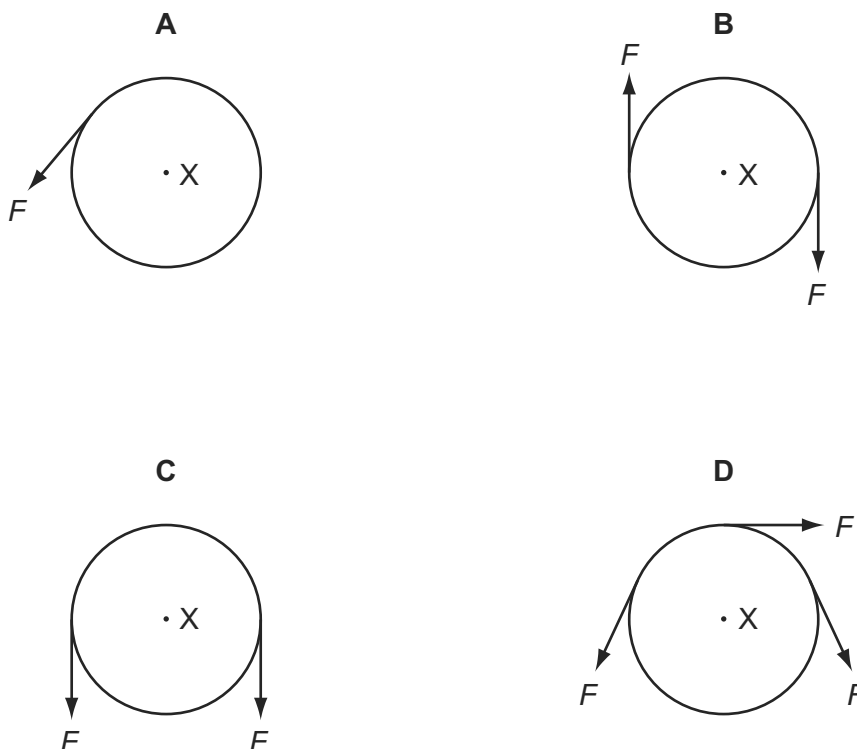
What is the order of increasing magnitude of these three forces?

- A** upthrust $\rightarrow$ viscous drag $\rightarrow$ weight
B viscous drag $\rightarrow$ upthrust $\rightarrow$ weight
C viscous drag $\rightarrow$ weight $\rightarrow$ upthrust
D weight $\rightarrow$ upthrust $\rightarrow$ viscous drag

- 35 A rigid circular disc of radius r has its centre at X . A number of forces of equal magnitude F act at the edge of the disc. All the forces are in the plane of the disc.

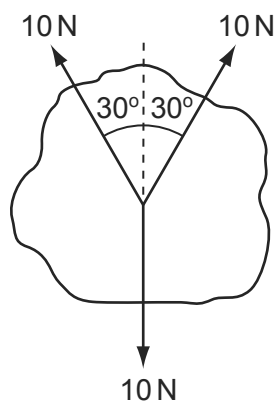
9702/01/O/N/06/Q14

Which arrangement of forces provides a moment of magnitude $2Fr$ about X ?



- 36 Three coplanar forces, each of magnitude 10 N , act through the same point of a body in the directions shown.

9702/01/O/N/06/Q15



What is the magnitude of the resultant force?

- A 0 N B 1.3 N C 7.3 N D 10 N
- 37 A supermarket trolley, total mass 30 kg , is moving at 3.0 m s^{-1} . A retarding force of 60 N is applied to the trolley for 0.50 s in the opposite direction to the trolley's initial velocity.

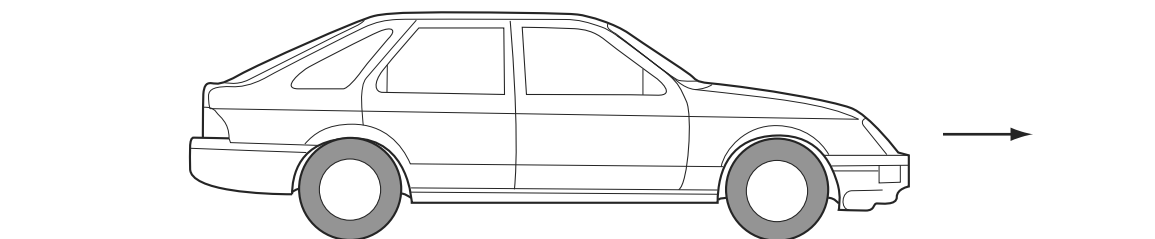
9702/12/O/N/09/Q9

What is the trolley's new velocity after the application of the force?

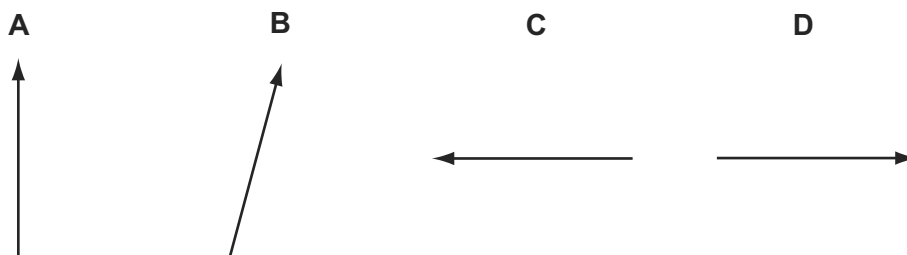
- A 1.0 m s^{-1} B 1.5 m s^{-1} C 2.0 m s^{-1} D 2.8 m s^{-1}

- 38 A car with front-wheel drive accelerates in the direction shown.

9702/01/O/N/07/Q11

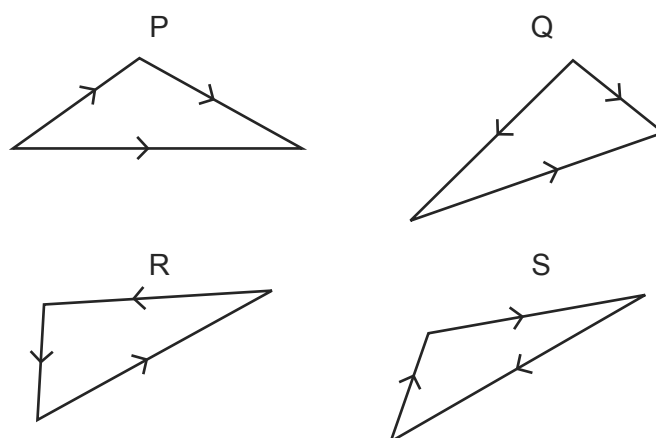


Which diagram best shows the direction of the total force exerted by the road on the front wheels?



- 39 Which two vector diagrams represent forces in equilibrium?

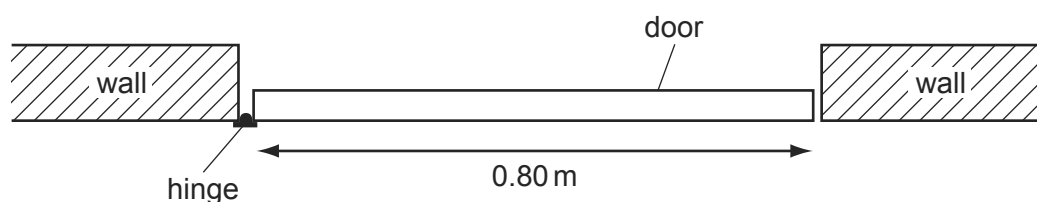
9702/01/O/N/07/Q13



- A** P and Q **B** Q and R **C** R and S **D** S and P

- 40 The diagram shows a plan view of a door which requires a moment of 12 N m to open it.

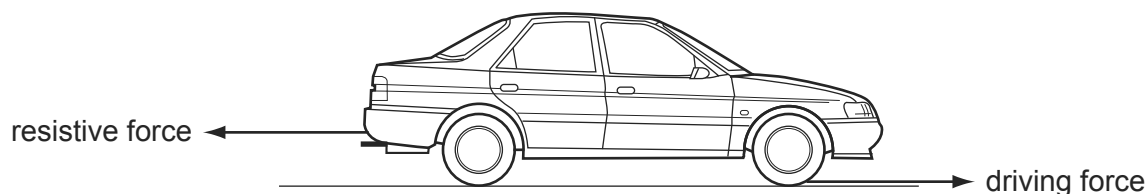
9702/01/O/N/07/Q14



What is the minimum force that must be applied at the door's midpoint to ensure it opens?

- A** 4.8 N **B** 9.6 N **C** 15 N **D** 30 N

- 41 A car of mass 750 kg has a horizontal driving force of 2.0 kN acting on it. It has a forward horizontal acceleration of 2.0 m s^{-2} . 9702/01/M/J/08/Q11

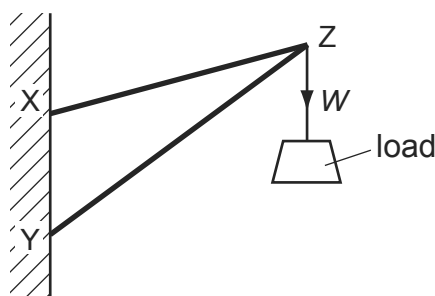


What is the resistive force acting horizontally?

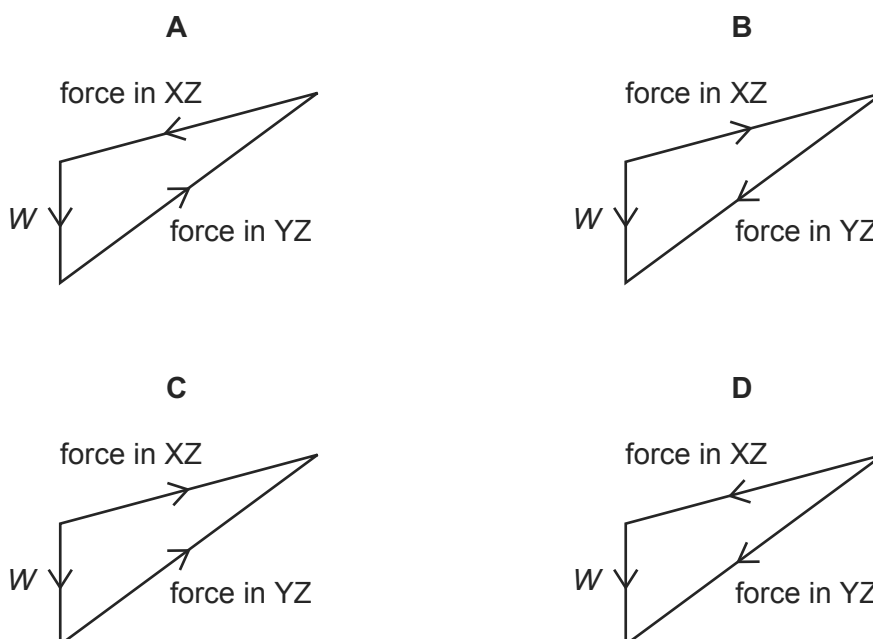
- A** 0.5 kN **B** 1.5 kN **C** 2.0 kN **D** 3.5 kN

- 42 Two rigid rods, XZ and YZ, are fixed to a vertical wall at points X and Y. 9702/01/M/J/08/Q13
A load of weight W is hung from point Z.

The load is not moving.

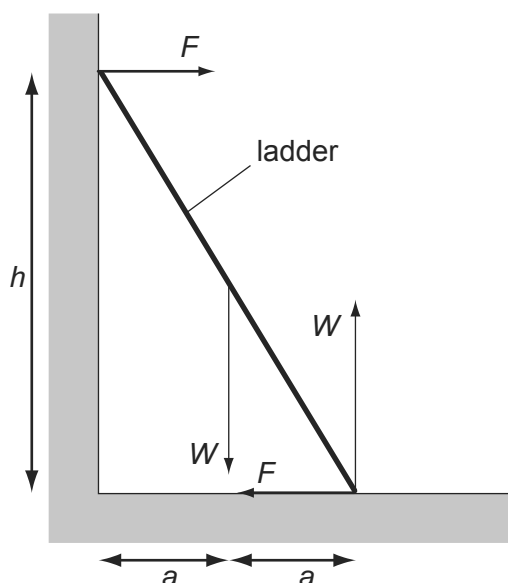


Which diagram shows the forces acting at point Z?



- 43 A uniform ladder rests against a vertical wall where there is negligible friction. The bottom of the ladder rests on rough ground where there is friction. The top of the ladder is at a height h above the ground and the foot of the ladder is at a distance $2a$ from the wall. 9702/01/M/J/08/Q14

The diagram shows the forces which act on the ladder.



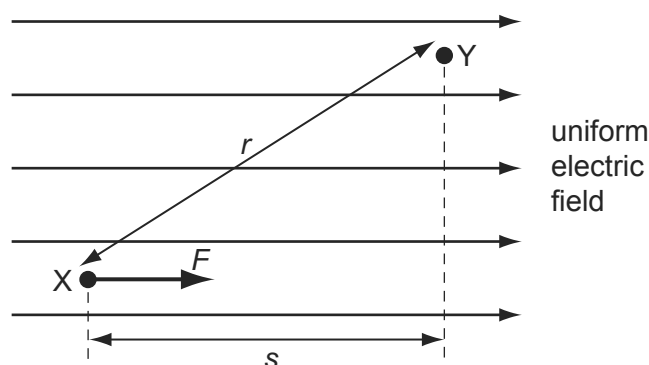
Which equation is formed by taking moments?

- A** $W_a + F_h = 2W_a$
- B** $F_a + W_a = F_h$
- C** $W_a + 2W_a = F_h$
- D** $W_a - 2W_a = 2F_h$

- 44 A positive charge experiences a force F when placed at point X in a uniform electric field.

The charge is then moved from point X to point Y.

Distances r and s are shown on the diagram.

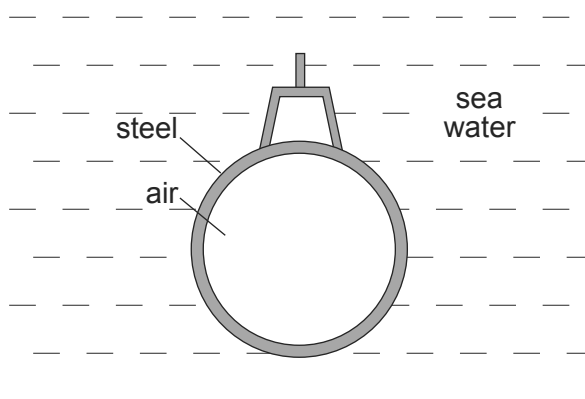


What is the change in the potential energy of the charge?

- A** decreases by F_s
B increases by F_s
C decreases by F_r
D increases by F_r

- 45 A submarine is in equilibrium in a fully submerged position.

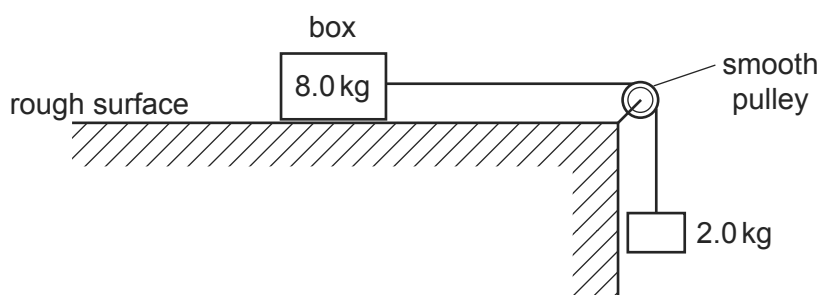
9702/01/M/J/08/Q15



What causes the upthrust on the submarine?

- A** The air in the submarine is less dense than sea water.
B The sea water exerts a greater upward force on the submarine than the weight of the steel.
C The submarine displaces its own volume of sea water.
D There is a difference in water pressure acting on the top and bottom of the submarine.
- 46 A box of mass 8.0 kg rests on a horizontal, rough surface. A string attached to the box passes over a smooth pulley and supports a 2.0 kg mass at its other end.

9702/01/O/N/08/Q11



When the box is released, a friction force of 6.0 N acts on it.

What is the acceleration of the box?

- A** 1.4 ms^{-2} **B** 1.7 ms^{-2} **C** 2.0 ms^{-2} **D** 2.5 ms^{-2}
- 47 An object, made from two equal masses joined by a light rod, falls with uniform speed through air. The rod remains horizontal.

9702/01/M/J/09/Q12

Which statement about the equilibrium of the system is correct?

- A** It is not in equilibrium because it is falling steadily.
B It is not in equilibrium because it is in motion.
C It is not in equilibrium because there is a resultant torque.
D It is in equilibrium because there is no resultant force and no resultant torque.

- 48 A ball falls vertically and bounces on the ground.

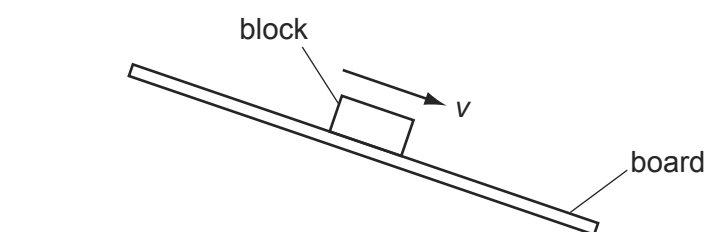
9702/01/O/N/08/Q9

The following statements are about the forces acting while the ball is in contact with the ground.

Which statement is correct?

- A** The force that the ball exerts on the ground is always equal to the weight of the ball.
- B** The force that the ball exerts on the ground is always equal in magnitude and opposite in direction to the force the ground exerts on the ball.
- C** The force that the ball exerts on the ground is always less than the weight of the ball.
- D** The weight of the ball is always equal in magnitude and opposite in direction to the force that the ground exerts on the ball.
- 49 A wooden block rests on a rough board. The end of the board is then raised until the block slides down the plane of the board at constant velocity v .

9702/01/O/N/08/Q12

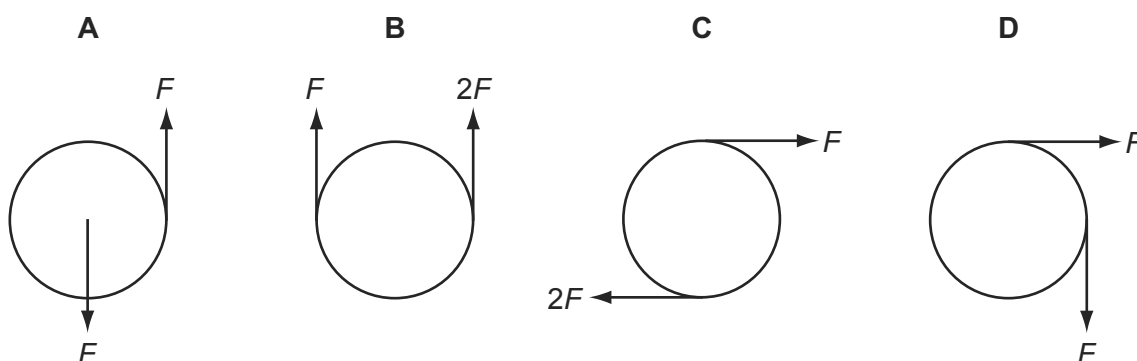


Which row describes the forces acting on the block when sliding with constant velocity?

	frictional force on block	resultant force on block
A	down the plane	down the plane
B	down the plane	zero
C	up the plane	down the plane
D	up the plane	zero

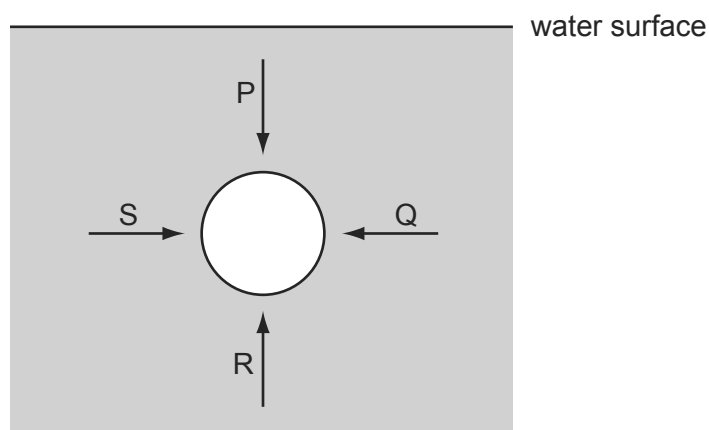
- 50 Which pair of forces acts as a couple on the circular object?

9702/01/O/N/08/Q14



- 51 The diagram represents a sphere under water. P, Q, R, and S are forces acting on the sphere, due to the pressure of the water.

9702/01/M/J/09/Q11

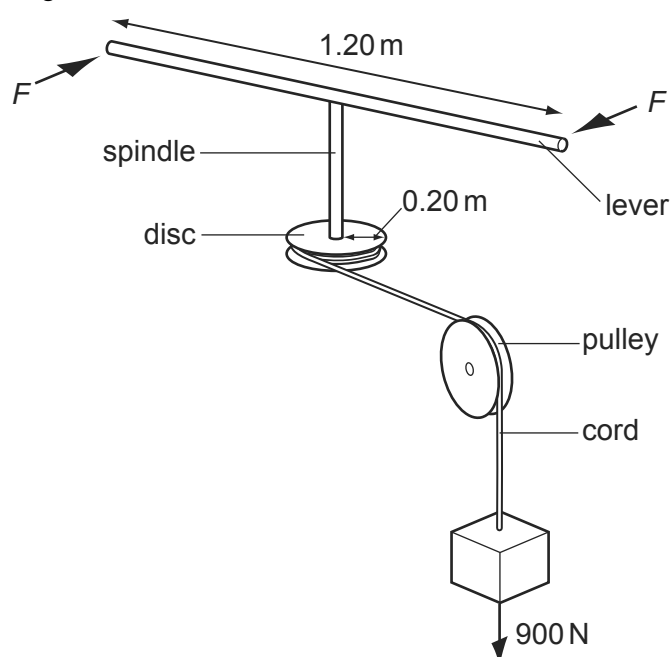


Each force acts perpendicularly to the sphere's surface. P and R act in opposite directions vertically. Q and S act in opposite directions horizontally.

Which information about the magnitudes of the forces is correct?

- A** $P < R$; $S = Q$
B $P > R$; $S = Q$
C $P = R$; $S = Q$
D $P = R = S = Q$
- 52 A spindle is attached at one end to the centre of a lever 1.20 m long and at its other end to the centre of a disc of radius 0.20 m. A cord is wrapped round the disc, passes over a pulley and is attached to a 900 N weight.

9702/01/M/J/09/Q13



What is the minimum force F , applied to each end of the lever, that could lift the weight?

- A** 75 N **B** 150 N **C** 300 N **D** 950 N

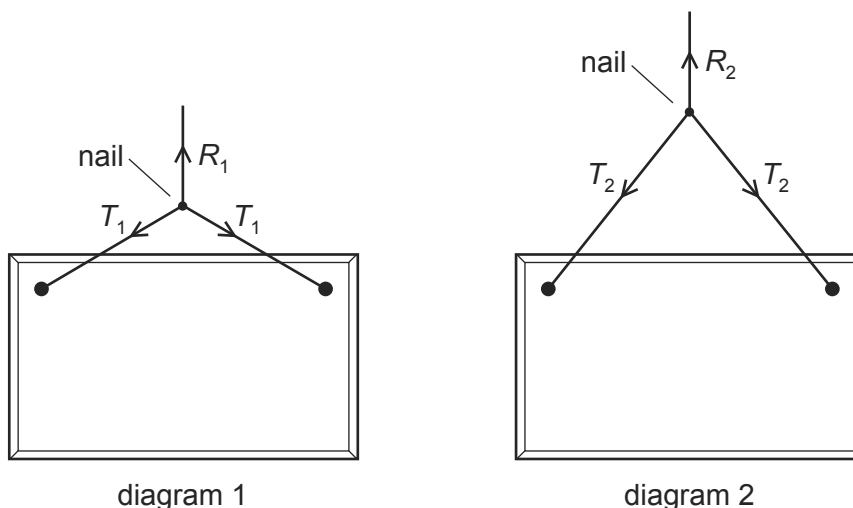
53 What is the centre of gravity of an object?

9702/11/O/N/09/Q11

- A** the geometrical centre of the object
- B** the point about which the total torque is zero
- C** the point at which the weight of the object may be considered to act
- D** the point through which gravity acts

54 The diagrams show two ways of hanging the same picture.

9702/11/O/N/09/Q12



In both cases, a string is attached to the same points on the picture and looped symmetrically over a nail in a wall. The forces shown are those that act on the nail.

In diagram 1, the string loop is shorter than in diagram 2.

Which information about the magnitude of the forces is correct?

- A** $R_1 = R_2$ $T_1 = T_2$
- B** $R_1 = R_2$ $T_1 > T_2$
- C** $R_1 > R_2$ $T_1 < T_2$
- D** $R_1 < R_2$ $T_1 = T_2$

55 An object, immersed in a liquid in a tank, experiences an upthrust.

9702/12/M/J/10/Q13

What is the physical reason for this upthrust?

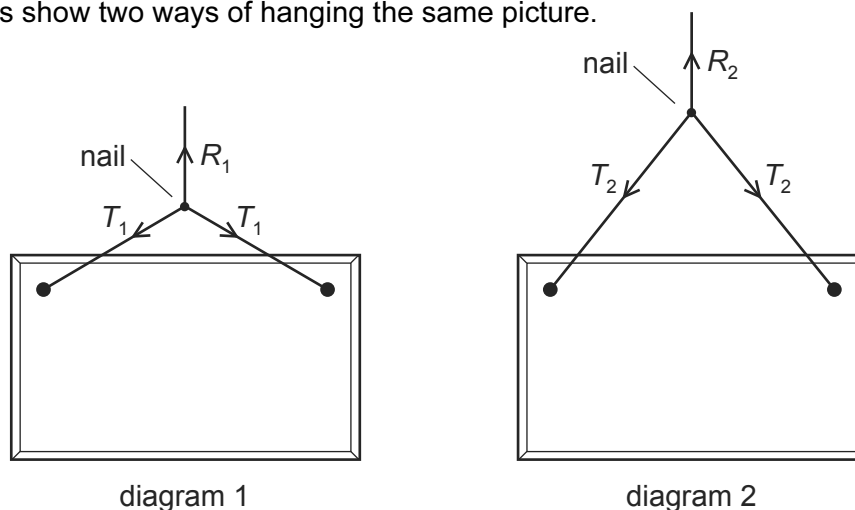
- A** The density of the body differs from that of the liquid.
- B** The density of the liquid increases with depth.
- C** The pressure in the liquid increases with depth.
- D** The value of g in the liquid increases with depth.

56 What is the centre of gravity of an object?

- A** the geometrical centre of the object
- B** the point about which the total torque is zero
- C** the point at which the weight of the object may be considered to act
- D** the point through which gravity acts

57 The diagrams show two ways of hanging the same picture.

9702/12/O/N/09/Q11



In both cases, a string is attached to the same points on the picture and looped symmetrically over a nail in a wall. The forces shown are those that act on the nail.

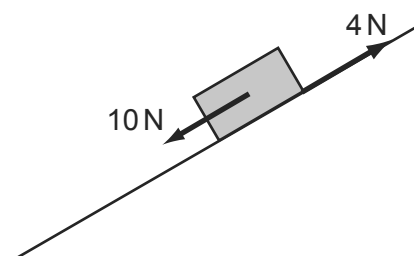
In diagram 1, the string loop is shorter than in diagram 2.

Which information about the magnitude of the forces is correct?

- A** $R_1 = R_2$ $T_1 = T_2$
- B** $R_1 = R_2$ $T_1 > T_2$
- C** $R_1 > R_2$ $T_1 < T_2$
- D** $R_1 < R_2$ $T_1 = T_2$

58 A brick weighing 20 N rests on an inclined plane. The weight of the brick has a component of 10 N parallel with the plane. The brick also experiences a frictional force of 4 N.

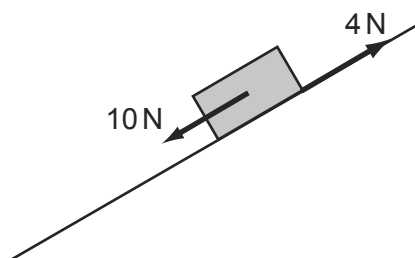
9702/11/M/J/10/Q11



What is the acceleration of the brick down the plane? Assume that the acceleration of free fall g is equal to 10 ms^{-2} .

- A** 0.3 ms^{-2}
- B** 0.8 ms^{-2}
- C** 3.0 ms^{-2}
- D** 8.0 ms^{-2}

- 59 A brick weighing 20 N rests on an inclined plane. The weight of the brick has a component of 10 N parallel with the plane. The brick also experiences a frictional force of 4 N. 9702/12/M/J/10/Q14

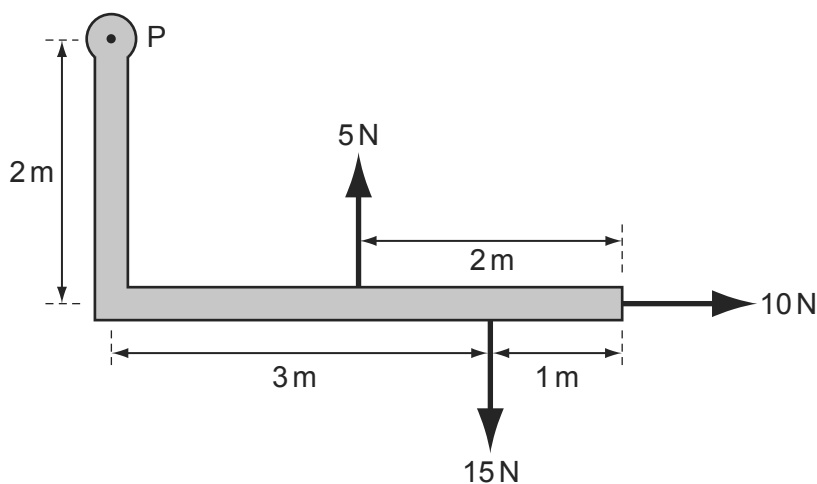


What is the acceleration of the brick down the plane? Assume that the acceleration of free fall g is equal to 10 ms^{-2} .

- A 0.3 ms^{-2} B 0.8 ms^{-2} C 3.0 ms^{-2} D 8.0 ms^{-2}
- 60 An object, immersed in a liquid in a tank, experiences an upthrust. 9702/13/M/J/10/Q10

What is the physical reason for this upthrust?

- A The density of the body differs from that of the liquid.
 B The density of the liquid increases with depth.
 C The pressure in the liquid increases with depth.
 D The value of g in the liquid increases with depth.
- 61 A rigid L-shaped lever arm is pivoted at point P. 9702/11/O/N/10/Q13



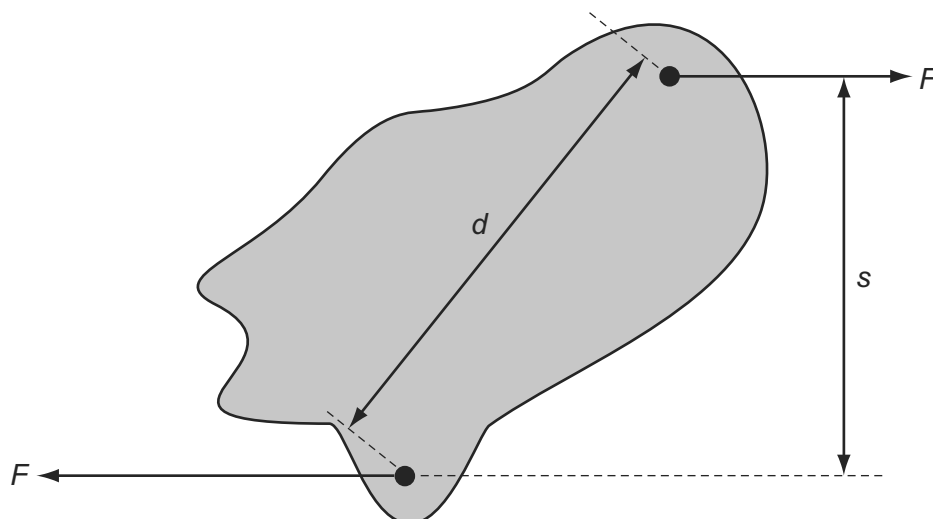
Three forces act on the lever arm, as shown in the diagram.

What is the magnitude of the resultant moment of these forces about point P?

- A 15 Nm B 20 Nm C 35 Nm D 75 Nm

62 Two parallel forces, each of magnitude F , act on a body as shown.

9702/11/O/N/10/Q14

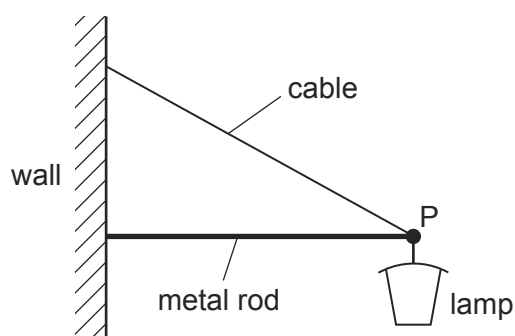


What is the magnitude of the torque on the body produced by these forces?

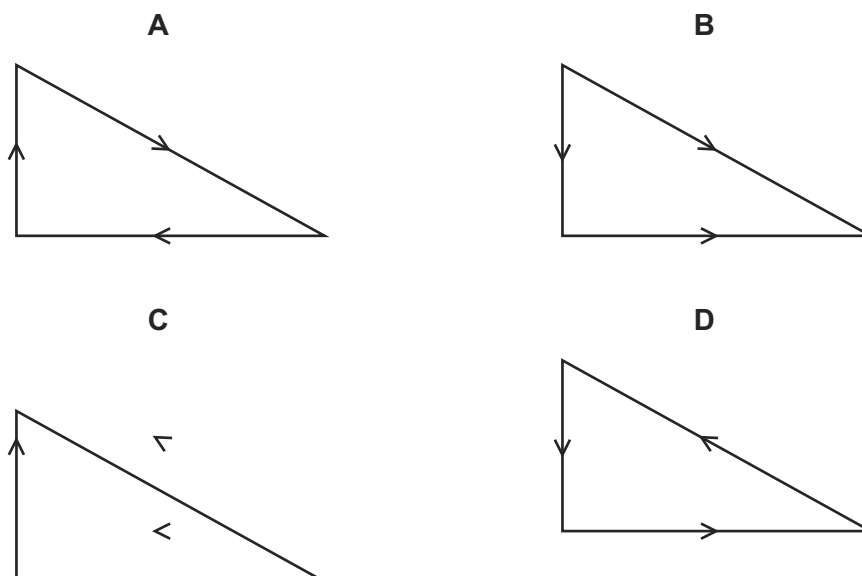
- A** Fd **B** Fs **C** $2Fd$ **D** $2Fs$

63 A street lamp is fixed to a wall by a metal rod and a cable.

9702/11/O/N/10/Q15

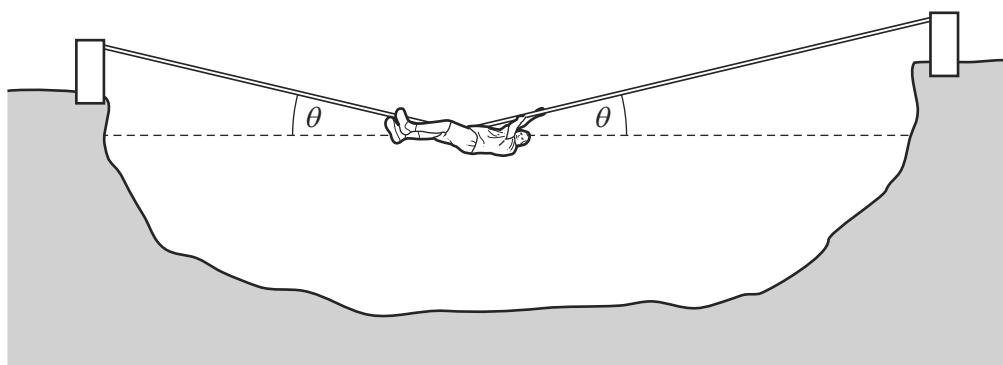


Which vector triangle represents the forces acting at point P?



- 64 The diagram shows a rope bridge that a student makes on an adventure training course. The student has a weight W .

9702/12/O/N/10/Q11

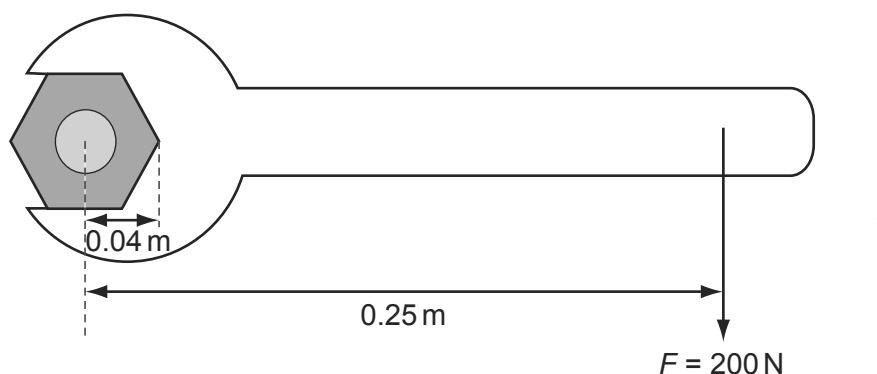


Which formula gives the tension T in the rope?

- A $T = \frac{W}{2 \cos \theta}$ B $T = \frac{W}{2 \sin \theta}$ C $T = \frac{W}{\cos \theta}$ D $T = \frac{W}{\sin \theta}$

- 65 A spanner is used to tighten a nut as shown.

9702/12/O/N/10/Q12

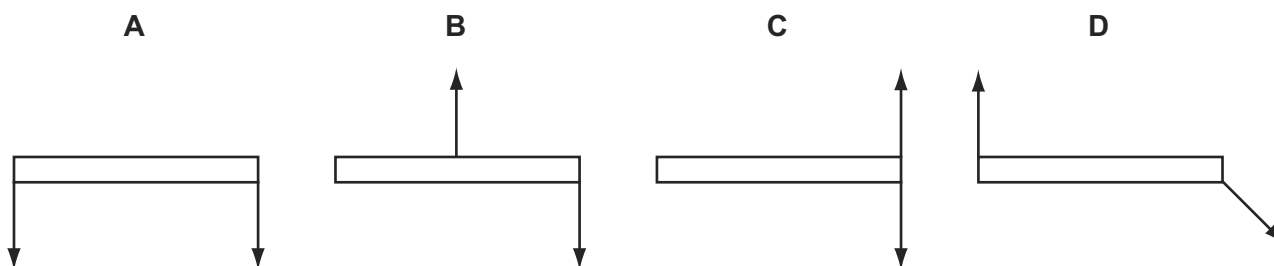


A force F is applied at right-angles to the spanner at a distance of 0.25 m from the centre of the nut. When the nut is fully tightened, the applied force is 200 N.

What is the resistive torque, in an anticlockwise direction, preventing further tightening?

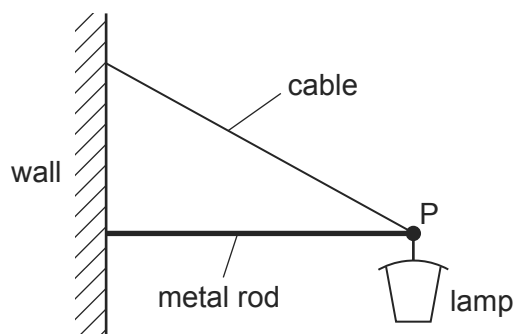
- A 8 Nm B 42 Nm C 50 Nm D 1250 Nm
- 66 The diagrams all show a pair of equal forces acting on a metre rule.

Which diagram shows forces that provide a couple and zero resultant force?

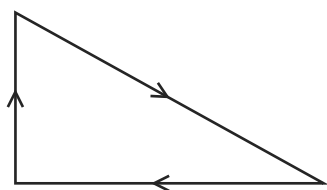
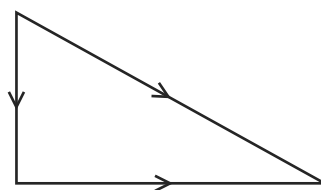
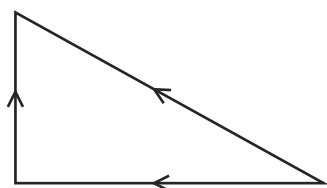
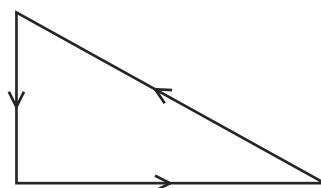


- 67 A street lamp is fixed to a wall by a metal rod and a cable.

9702/13/O/N/10/Q13

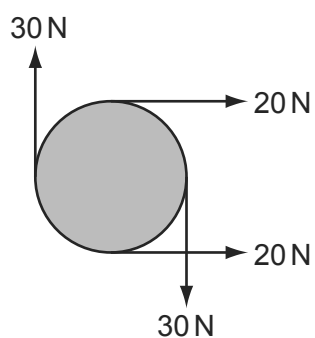


Which vector triangle represents the forces acting at point P?

A**B****C****D**

- 68 The diagram shows four forces applied to a circular object.

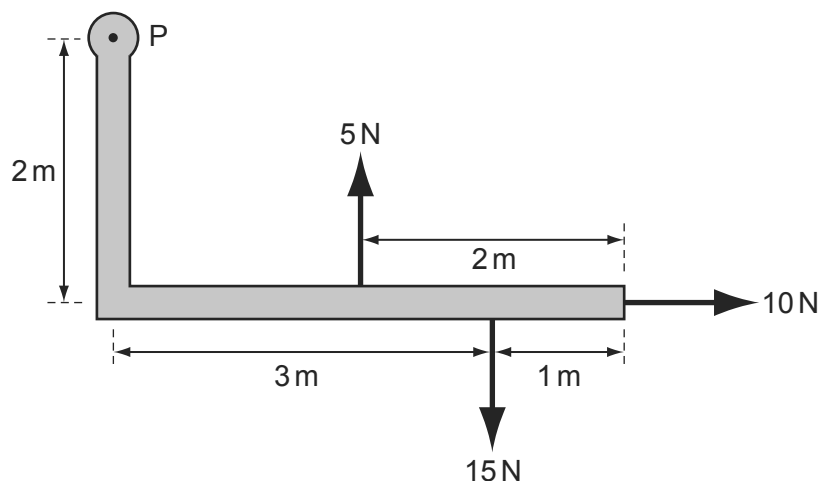
9702/11/M/J/11/Q12



Which row describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
A	zero	zero
B	zero	non-zero
C	non-zero	zero
D	non-zero	non-zero

- 69 A rigid L-shaped lever arm is pivoted at point P.



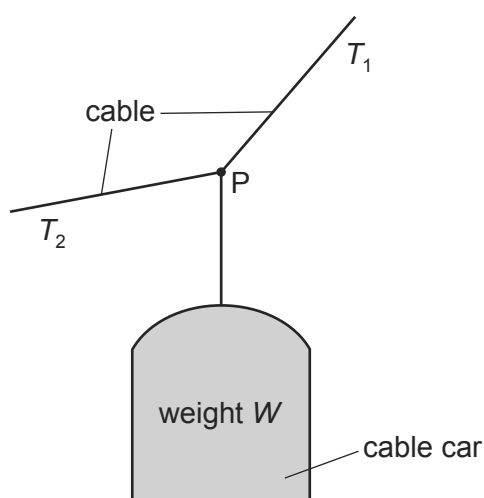
Three forces act on the lever arm, as shown in the diagram.

What is the magnitude of the resultant moment of these forces about point P?

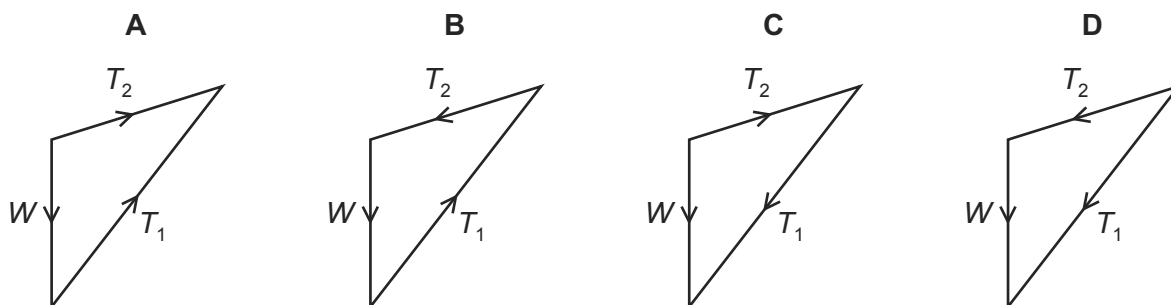
- A** 15 Nm **B** 20 Nm **C** 35 Nm **D** 75 Nm

- 70 A cable car of weight W hangs in equilibrium from its cable at point P.

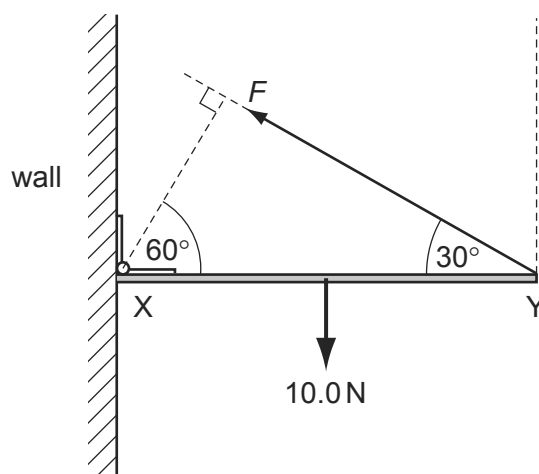
The cable has tensions T_1 and T_2 as shown.



Which diagram correctly represents the forces acting at point P?



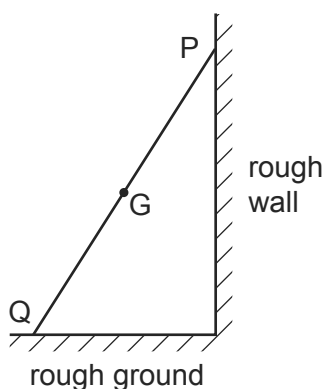
- 71 A uniform rod XY of weight 10.0 N is freely hinged to a wall at X. It is held horizontal by a force F acting from Y at an angle of 30° to the horizontal, as shown. 9702/12/M/J/11/Q16



What is the value of F ?

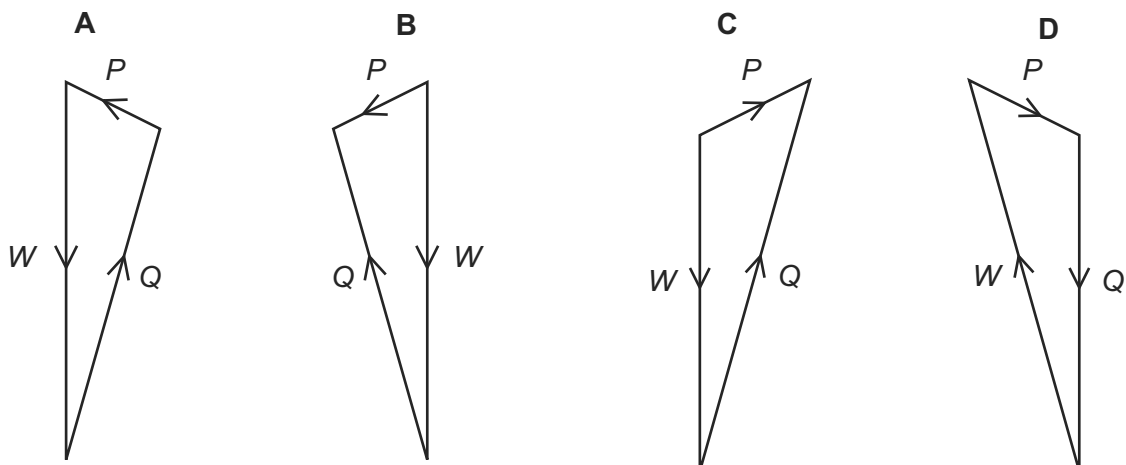
- 72 A ladder rests in equilibrium on rough ground against a rough wall.

9702/11/O/N/11/Q13



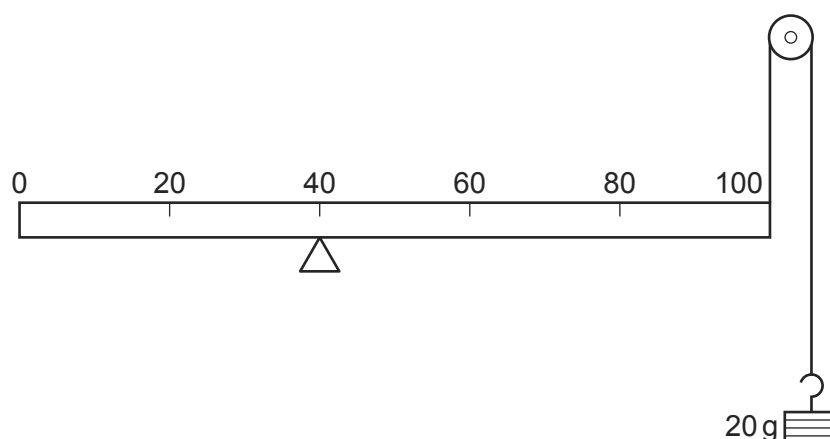
Its weight W acts through the centre of gravity G. Forces also act on the ladder at P and at Q. These forces are P and Q respectively.

Which vector triangle represents the forces on the ladder?



- 73 A uniform metre rule of mass 100 g is supported by a pivot at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram.

9702/11/M/J/11/Q13



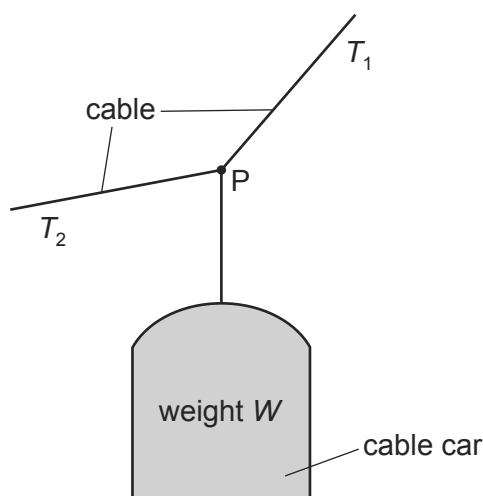
At which mark on the rule must a 50 g mass be suspended so that the rule balances?

- A** 4 cm **B** 36 cm **C** 44 cm **D** 64 cm

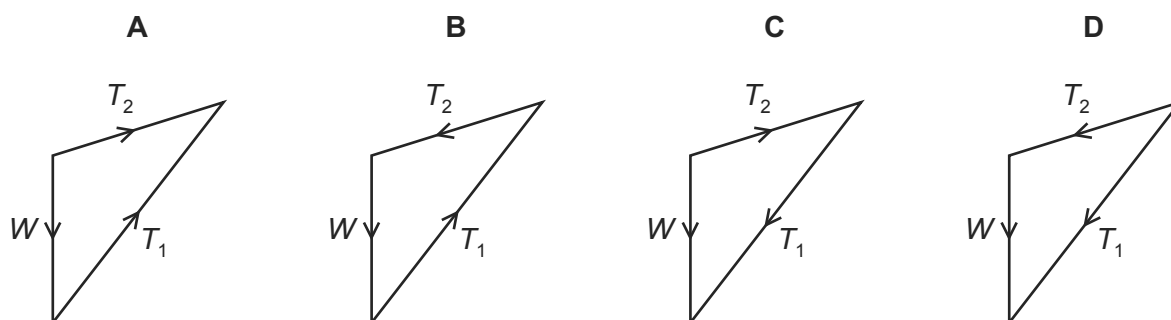
- 74 A cable car of weight W hangs in equilibrium from its cable at point P.

9702/13/M/J/11/Q13

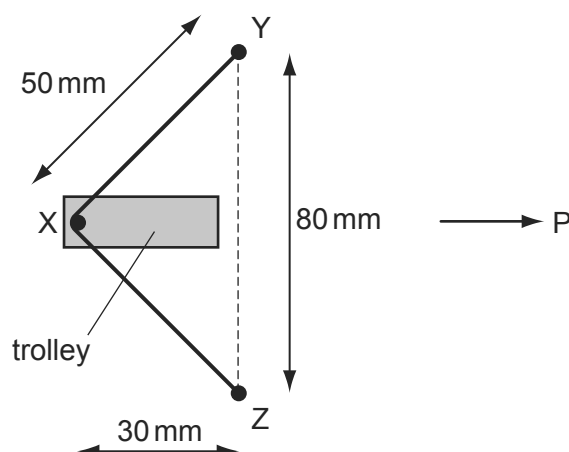
The cable has tensions T_1 and T_2 as shown.



Which diagram correctly represents the forces acting at point P?



- 75 The diagram shows two fixed pins, Y and Z. A length of elastic is stretched between Y and Z and around pin X, which is attached to a trolley. 9702/12/M/J/11/Q17

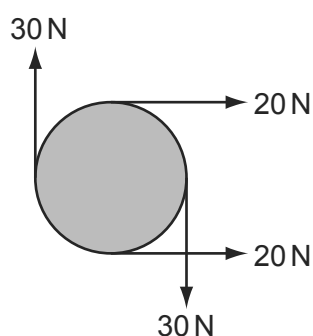


X is at the centre of the elastic and the trolley is to be propelled in the direction P at right angles to YZ. The tension in the elastic is 4 N.

What is the force accelerating the trolley in the direction P when the trolley is released?

- A** 2.4 N **B** 3.2 N **C** 4.8 N **D** 6.4 N

- 76 The diagram shows four forces applied to a circular object. 9702/13/M/J/11/Q11

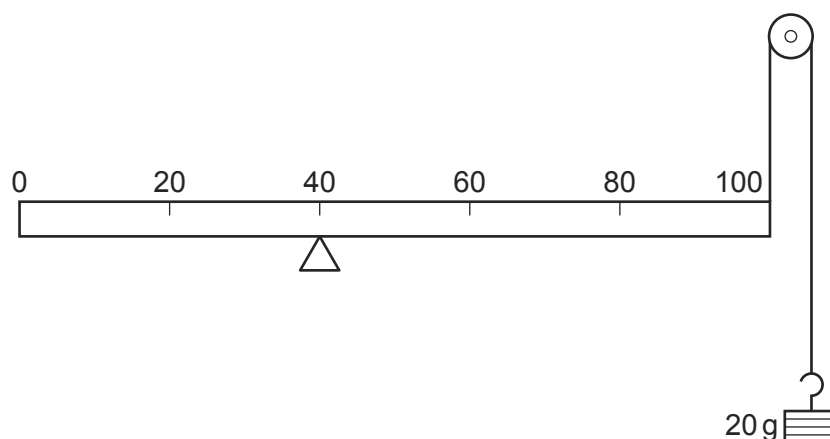


Which row describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
A	zero	zero
B	zero	non-zero
C	non-zero	zero
D	non-zero	non-zero

- 77 A uniform metre rule of mass 100 g is supported by a pivot at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram.

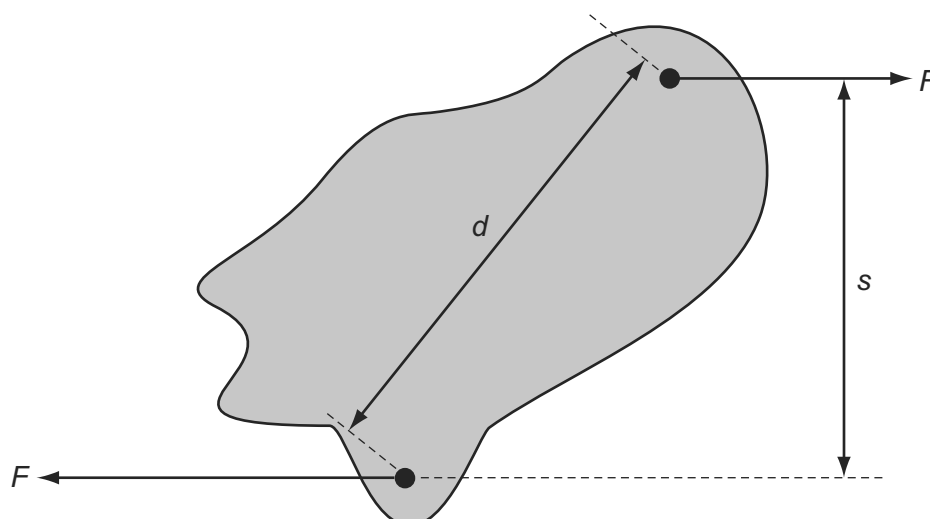
9702/13/M/J/11/Q12



At which mark on the rule must a 50 g mass be suspended so that the rule balances?

- A** 4 cm **B** 36 cm **C** 44 cm **D** 64 cm
- 78 Two parallel forces, each of magnitude F , act on a body as shown.

9702/13/O/N/10/Q15

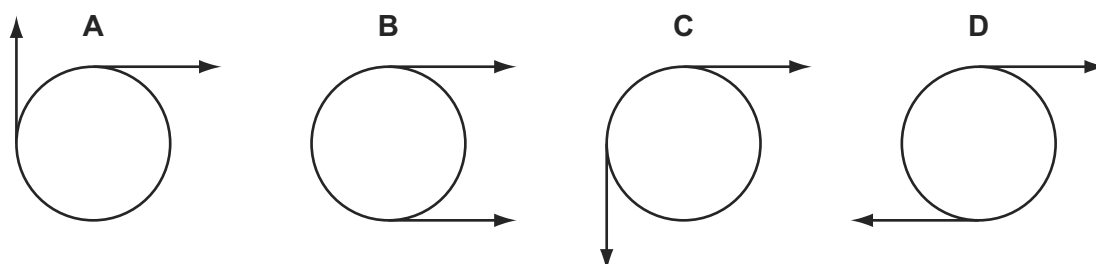


What is the magnitude of the torque on the body produced by these forces?

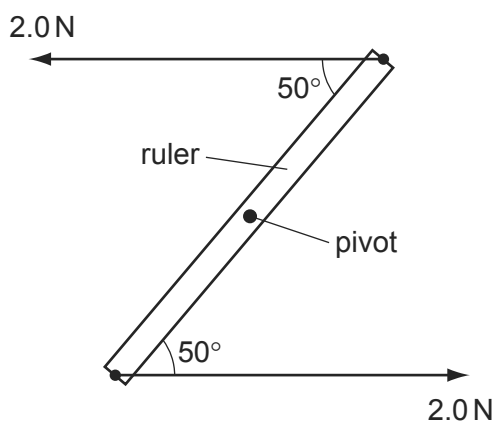
- A** Fd **B** Fs **C** $2Fd$ **D** $2Fs$
- 79 Two co-planar forces act on the rim of a wheel. The forces are equal in magnitude.

9702/12/O/N/11/Q13

Which arrangement of forces provides only a couple?

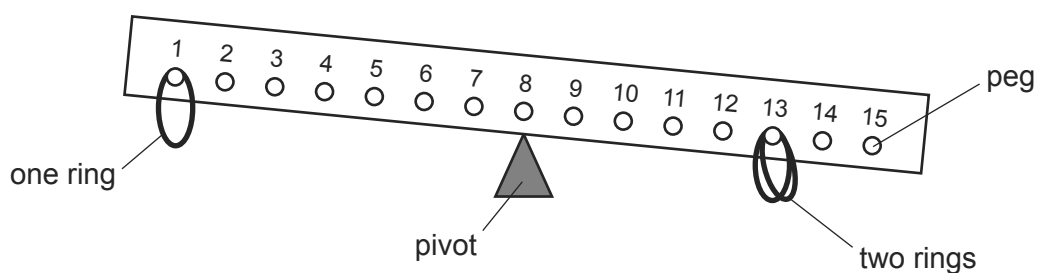


- 80 A ruler of length 0.30 m is pivoted at its centre. Equal and opposite forces of magnitude 2.0 N are applied to the ends of the ruler, creating a couple as shown. 9702/11/O/N/11/Q14



What is the magnitude of the torque of the couple on the ruler when it is in the position shown?

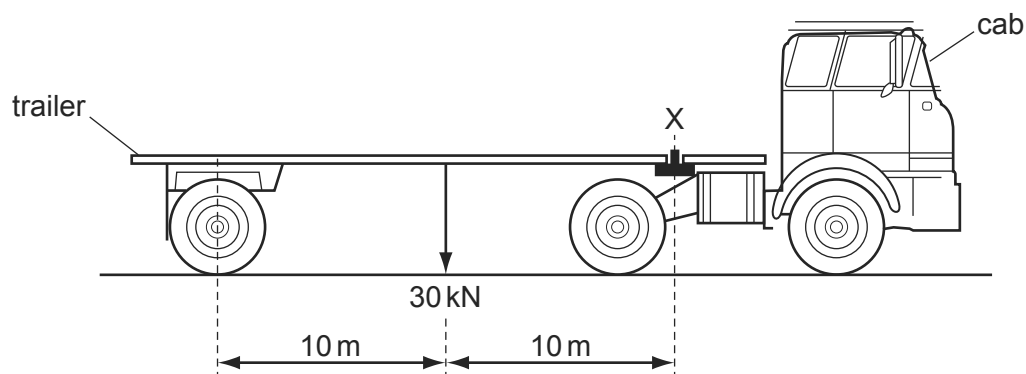
- 81 The diagram shows a child's balancing game. 9702/11/O/N/11/Q15



The wooden rod is uniform and all the rings are of equal mass. Two rings are hung on peg 13 and one on peg 1.

On which hook must a fourth ring be hung in order to balance the rod?

- 82 A trailer of weight 30 kN is hitched to a cab at X, as shown in the diagram. 9702/12/O/N/11/Q14

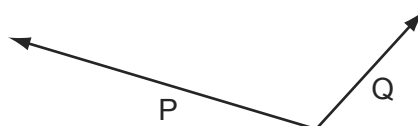


What is the upward force exerted by the cab on the trailer at X?

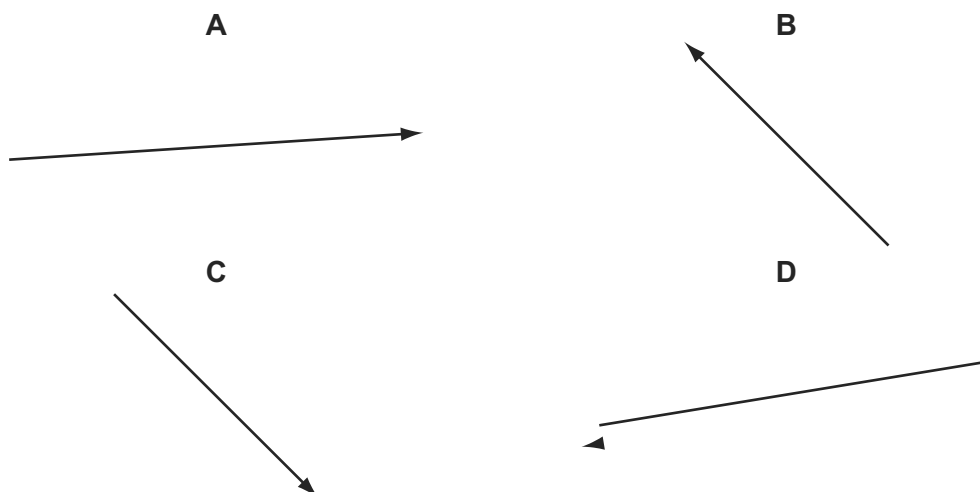
- A 3 kN B 15 kN C 30 kN D 60 kN

- 83 Two possible displacements of an object are represented by the vectors P and Q.

9702/12/O/N/11/Q12

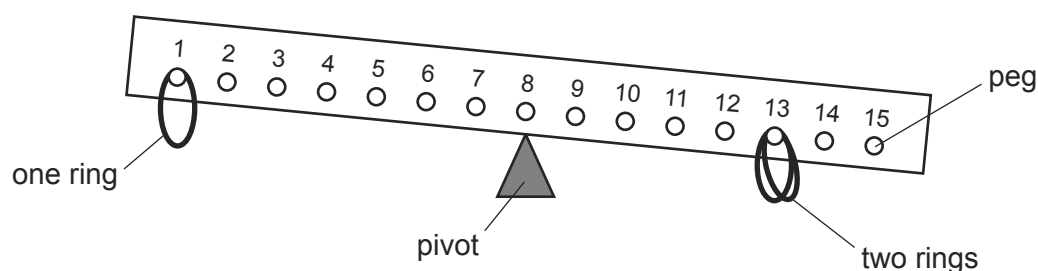


Which vector best represents the resultant displacement ($P - Q$) of the object?



- 84 The diagram shows a child's balancing game.

9702/13/O/N/11/Q13



The wooden rod is uniform and all the rings are of equal mass. Two rings are hung on peg 13 and one on peg 1.

On which hook must a fourth ring be hung in order to balance the rod?

- A** 2 **B** 3 **C** 5 **D** 6

- 85 A cylindrical block of wood has cross-sectional area A and weight W . It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively.

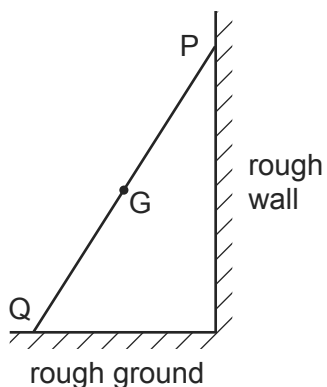
9702/11/M/J/12/Q13

Which expression is equal to the upthrust on the block?

- A** $(p_b - p_t)A + W$
B $(p_b - p_t)$
C $(p_b - p_t)A$
D $(p_b - p_t)A - W$

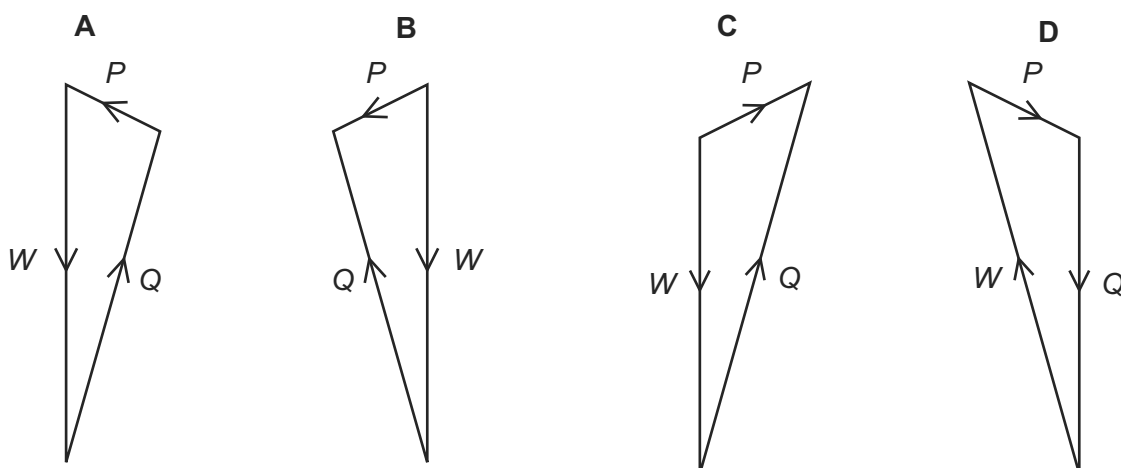
86 A ladder rests in equilibrium on rough ground against a rough wall.

9702/13/O/N/11/Q14



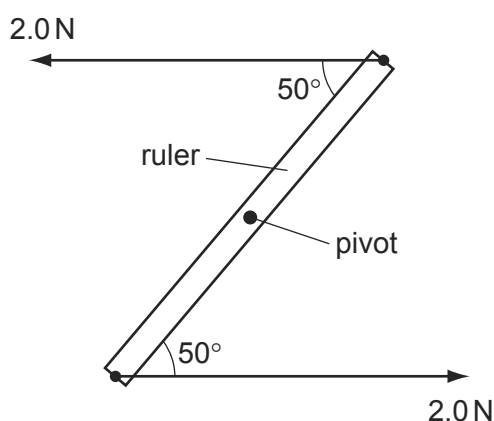
Its weight W acts through the centre of gravity G . Forces also act on the ladder at P and at Q . These forces are P and Q respectively.

Which vector triangle represents the forces on the ladder?



87 A ruler of length 0.30 m is pivoted at its centre. Equal and opposite forces of magnitude 2.0 N are applied to the ends of the ruler, creating a couple as shown.

9702/13/O/N/11/Q15

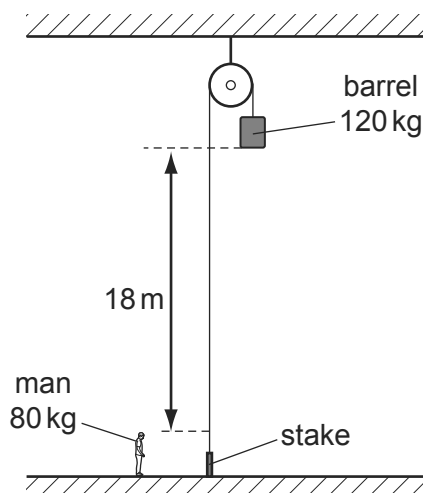


What is the magnitude of the torque of the couple on the ruler when it is in the position shown?

- A** 0.23 N m **B** 0.39 N m **C** 0.46 N m **D** 0.60 N m

- 88 The diagram shows a barrel suspended from a frictionless pulley on a building. The rope supporting the barrel goes over the pulley and is secured to a stake at the bottom of the building.

9702/11/M/J/12/Q12



A man stands close to the stake. The bottom of the barrel is 18 m above the man's head. The mass of the barrel is 120 kg and the mass of the man is 80 kg.

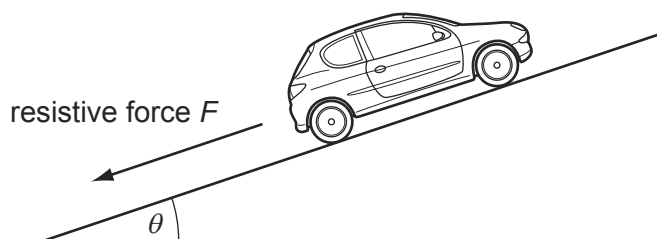
The man keeps hold of the rope after untying it from the stake and is lifted upwards as the barrel falls.

What is the man's upward speed when his head is level with the bottom of the barrel? (Use $g = 10 \text{ m s}^{-2}$.)

- A** 6 m s^{-1} **B** 8 m s^{-1} **C** 13 m s^{-1} **D** 19 m s^{-1}

- 89 A car of mass m travels at constant speed up a slope at an angle θ to the horizontal, as shown in the diagram. Air resistance and friction provide a resistive force F .

9702/11/M/J/12/Q14

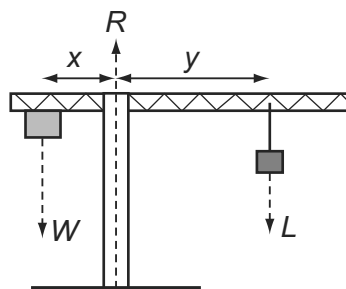


What force is needed to propel the car at this constant speed?

- A** $mg \cos \theta$
B $mg \sin \theta$
C $mg \cos \theta + F$
D $mg \sin \theta + F$

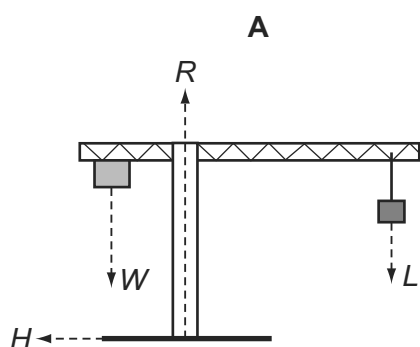
90 The diagram shows a crane supporting a load L .

9702/11/M/J/12/Q15

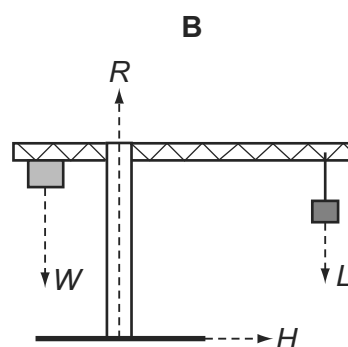


A mass provides a balancing load W . The position of the load is such that the system is perfectly balanced with $Wx = Ly$. The ground provides a reaction force R . The distance x does not change.

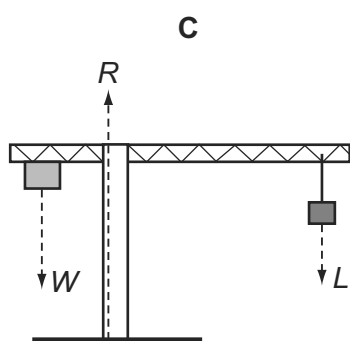
If the load is moved further out so that the distance y increases and the crane does not topple, which statement is correct?



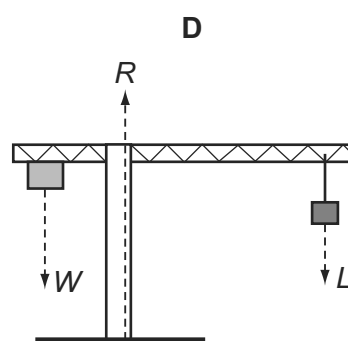
A horizontal force H acts on the base of the support column towards the left.



A horizontal force H acts on the base of the support column towards the right.



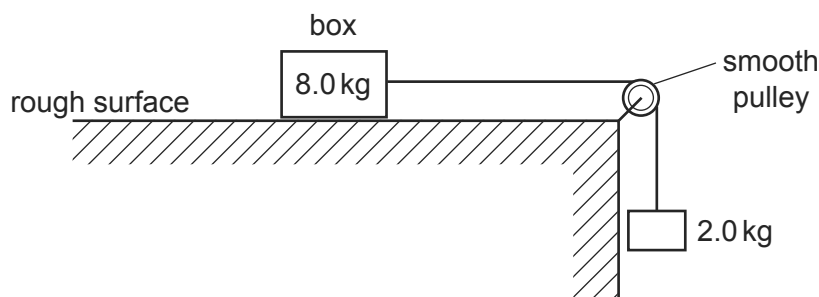
The reaction force R moves to the left.



The reaction force R moves to the right.

- 91 A box of mass 8.0 kg rests on a horizontal, rough surface. A string attached to the box passes over a smooth pulley and supports a 2.0 kg mass at its other end.

9702/12/M/J/12/Q13



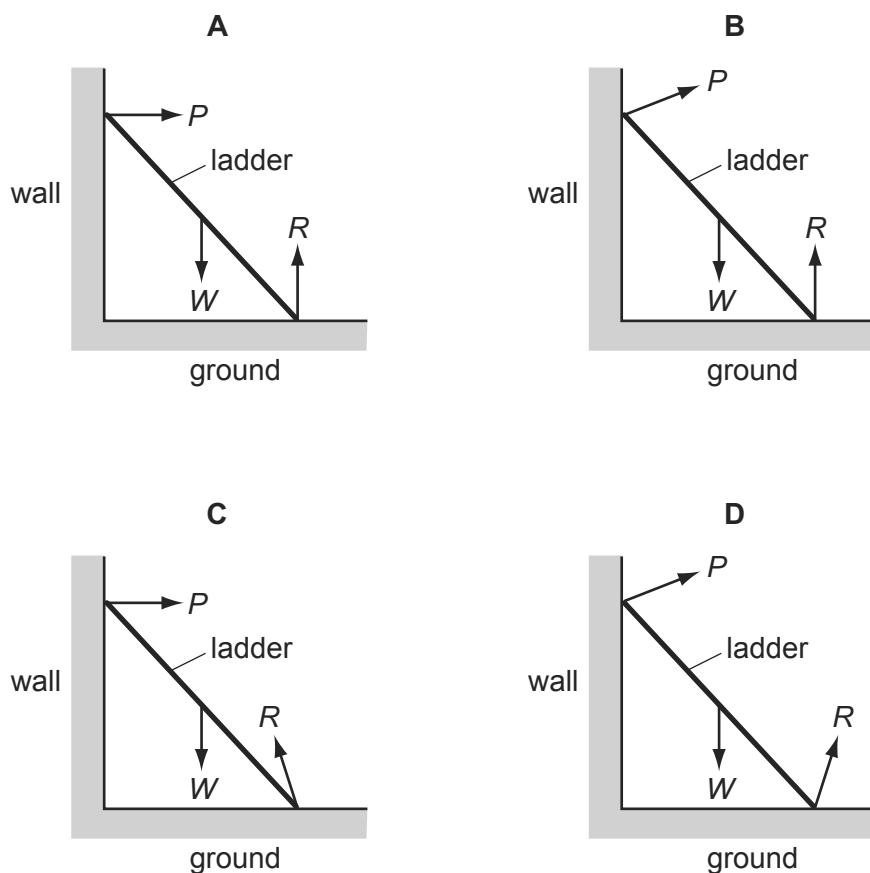
When the box is released, a frictional force of 6.0 N acts on it.

What is the acceleration of the box?

- A** 1.4 ms^{-2} **B** 1.7 ms^{-2} **C** 2.0 ms^{-2} **D** 2.5 ms^{-2}
- 92 A ladder is positioned on icy (frictionless) ground and is leant against a rough wall. At the instant of release it begins to slide.

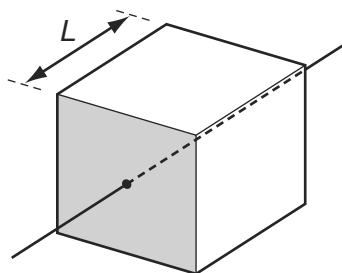
9702/12/M/J/12/Q14

Which diagram correctly shows the directions of the forces P , W and R acting on the ladder as it begins to slide?

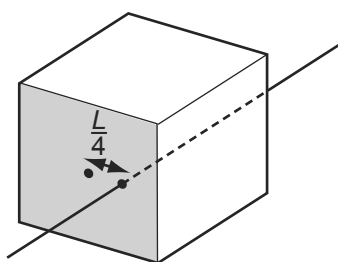


- 93 The diagram shows a solid cube with weight W and sides of length L . It is supported by a frictionless spindle that passes through the centres of two opposite vertical faces. One of these faces is shaded.

9702/12/M/J/12/Q15



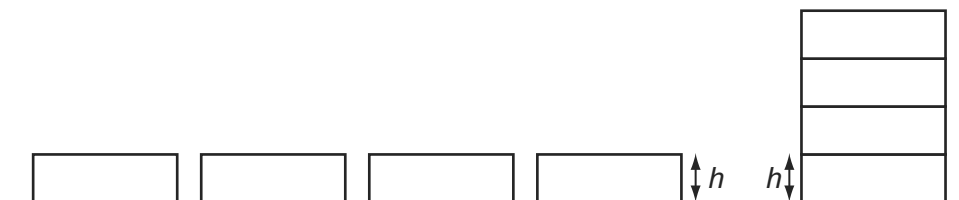
The spindle is now removed and replaced at a distance $\frac{L}{4}$ to the right of its original position.



When viewing the shaded face, what is the torque of the couple that will now be needed to stop the cube from toppling?

- A $\frac{WL}{2}$ anticlockwise
- B $\frac{WL}{2}$ clockwise
- C $\frac{WL}{4}$ anticlockwise
- D $\frac{WL}{4}$ clockwise
- 94 Initially, four identical uniform blocks, each of mass m and thickness h , are spread on a table.

9702/12/M/J/12/Q17



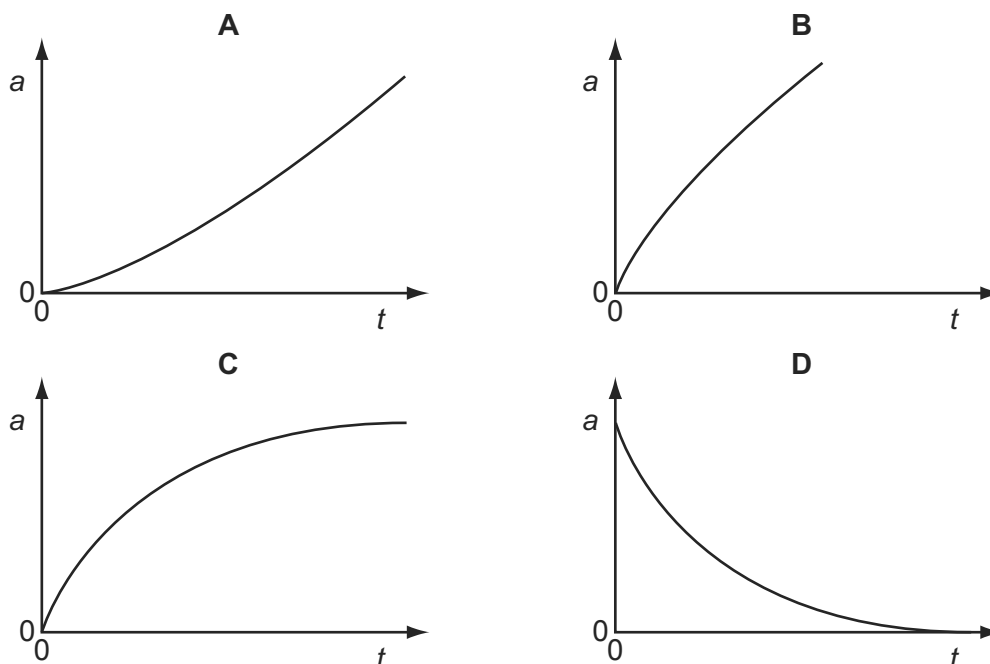
How much work is done on the blocks in stacking them on top of one another?

- A $3mgh$ B $6mgh$ C $8mgh$ D $10mgh$

95 A sphere is released from rest in a viscous fluid.

9702/12/M/J/12/Q16

Which graph represents the variation with time t of the acceleration a of the sphere?



96 Each option gives a correct word equation involving force.

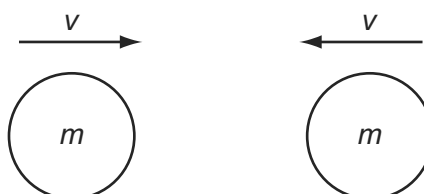
9702/13/M/J/12/Q11

Which option gives the definition of force?

- A** force = energy divided by displacement
- B** force = mass $\times$ acceleration
- C** force = pressure $\times$ area
- D** force = rate of change of momentum

97 Two similar spheres, each of mass m and travelling with speed v , are moving towards each other.

9702/13/M/J/12/Q12



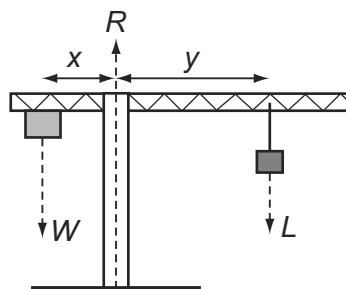
The spheres have a head-on elastic collision.

Which statement is correct?

- A** The spheres stick together on impact.
- B** The total kinetic energy after impact is mv^2 .
- C** The total kinetic energy before impact is zero.
- D** The total momentum before impact is $2mv$.

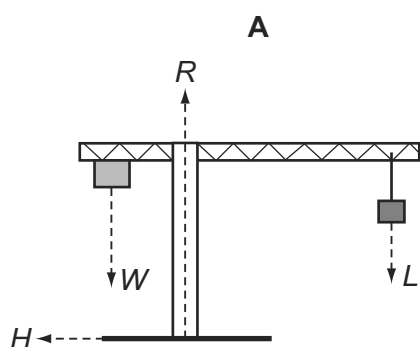
98 The diagram shows a crane supporting a load L .

9702/13/M/J/12/Q13

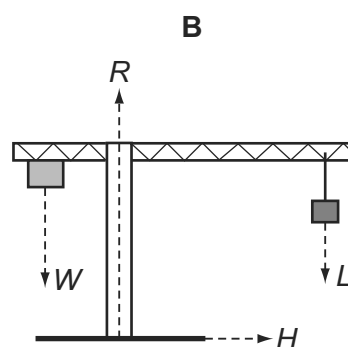


A mass provides a balancing load W . The position of the load is such that the system is perfectly balanced with $Wx = Ly$. The ground provides a reaction force R . The distance x does not change.

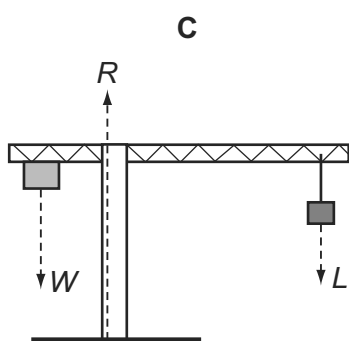
If the load is moved further out so that the distance y increases and the crane does not topple, which statement is correct?



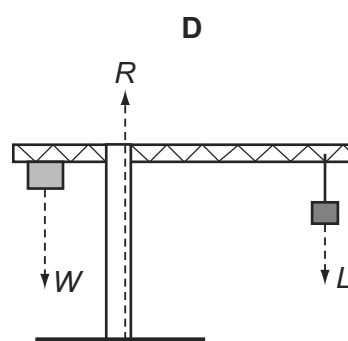
A horizontal force H acts on the base of the support column towards the left.



A horizontal force H acts on the base of the support column towards the right.



The reaction force R moves to the left.



The reaction force R moves to the right.

- 99 A cylindrical block of wood has cross-sectional area A and weight W . It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively.

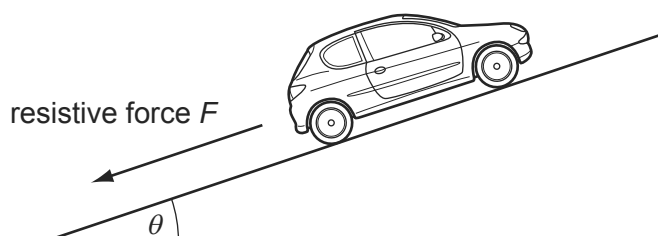
9702/13/M/J/12/Q14

Which expression is equal to the upthrust on the block?

- A $(p_b - p_t)A + W$
- B $(p_b - p_t)$
- C $(p_b - p_t)A$
- D $(p_b - p_t)A - W$

- 100 A car of mass m travels at constant speed up a slope at an angle θ to the horizontal, as shown in the diagram. Air resistance and friction provide a resistive force F .

9702/13/M/J/12/Q15



What force is needed to propel the car at this constant speed?

- A $mg \cos \theta$
- B $mg \sin \theta$
- C $mg \cos \theta + F$
- D $mg \sin \theta + F$

- 101 A lorry of mass 20 000 kg has a constant resultant force F acting on it.

9702/12/O/N/12/Q15

It accelerates from 6.0 m s^{-1} to 30.0 m s^{-1} in a time of 300 s.

What is the change in momentum of the lorry and the value of F ?

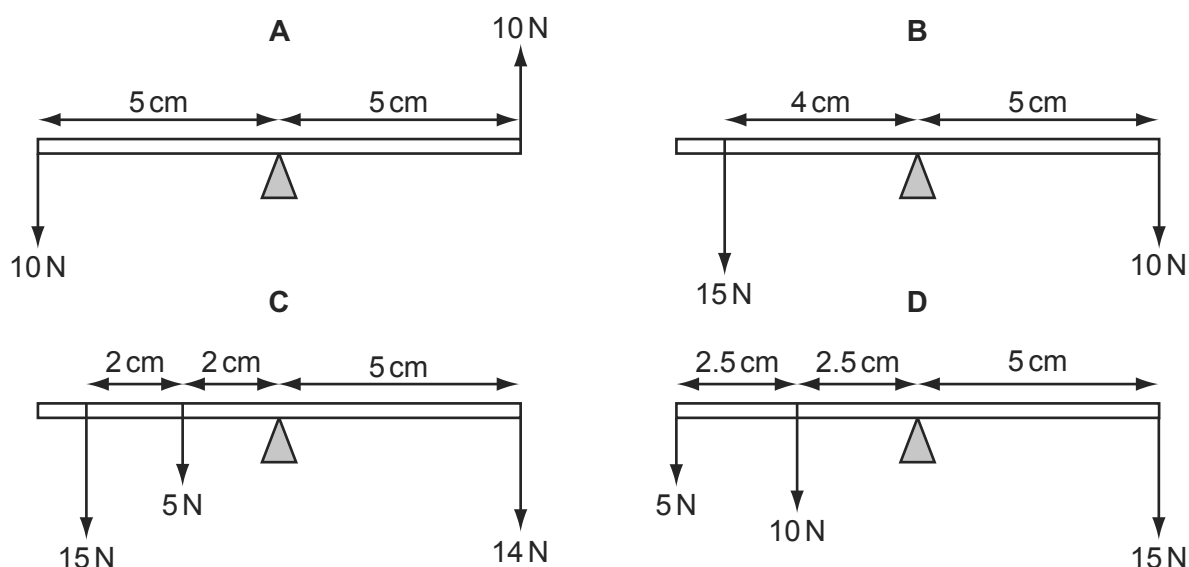
	change in momentum / N s	force F / N
A	48 000	160
B	480 000	1600
C	600 000	2000
D	600 000	20 000

102 A rigid uniform beam is pivoted horizontally at its midpoint.

9702/12/O/N/12/Q17

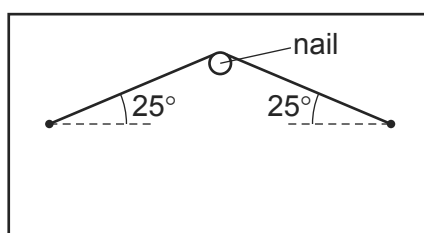
Different vertical forces are applied to different positions on the beam.

In which diagram is the beam in equilibrium?



103 A picture on a wall is supported by a wire looped over a nail.

9702/12/O/N/12/Q18



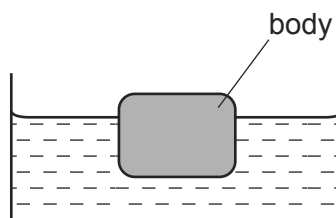
The mass of the picture is 4.2 kg.

What is the tension in the supporting wire?

- A** 5.0 N **B** 23 N **C** 49 N **D** 97 N

104 A stationary body floats in water.

9702/12/O/N/12/Q16

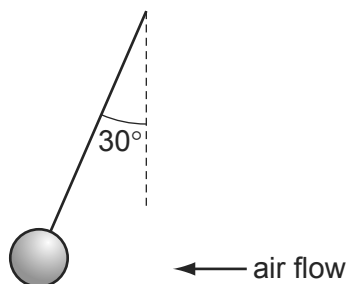


Which statement about the forces acting on the body is correct?

- A** The gravitational force is equal to the viscous force.
B The gravitational force is greater than the upthrust.
C The upthrust is zero.
D The viscous force is zero.

- 105 The diagram shows an experiment to measure the force exerted on a ball by a horizontal air flow.

9702/11/O/N/12/Q15



The ball is suspended by a light string and weighs 0.15 N.

The deflection of the string from vertical is 30° .

What is the force on the ball from the air flow?

- A** 0.075 N **B** 0.087 N **C** 0.26 N **D** 0.30 N

- 106 A student balances a 30 cm ruler on a fulcrum set at the 15 cm mark. She then places a 50 g mass on the 23 cm mark and a 20 g mass on the 11 cm mark, as shown.

9702/11/O/N/12/Q16



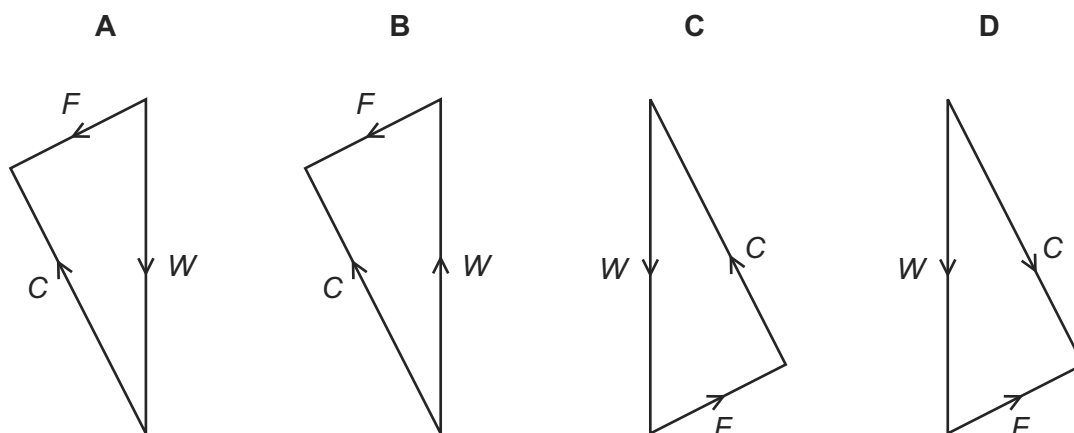
Which mass should she place on the 7 cm mark to restore the balance?

- A** 30 g **B** 40 g **C** 47 g **D** 133 g

- 107 A sledge slides down a slope at a constant velocity. The three forces that act on the sledge are the normal contact force C , the weight W and a constant frictional force F .

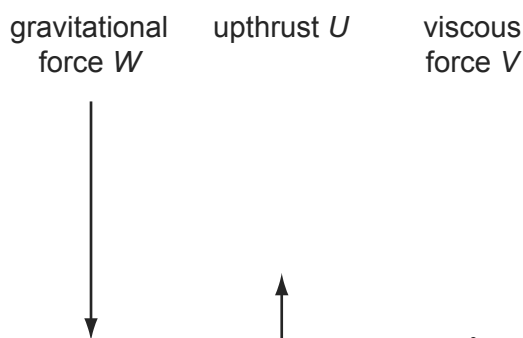
9702/11/O/N/12/Q17

Which diagram represents these forces acting on the sledge?

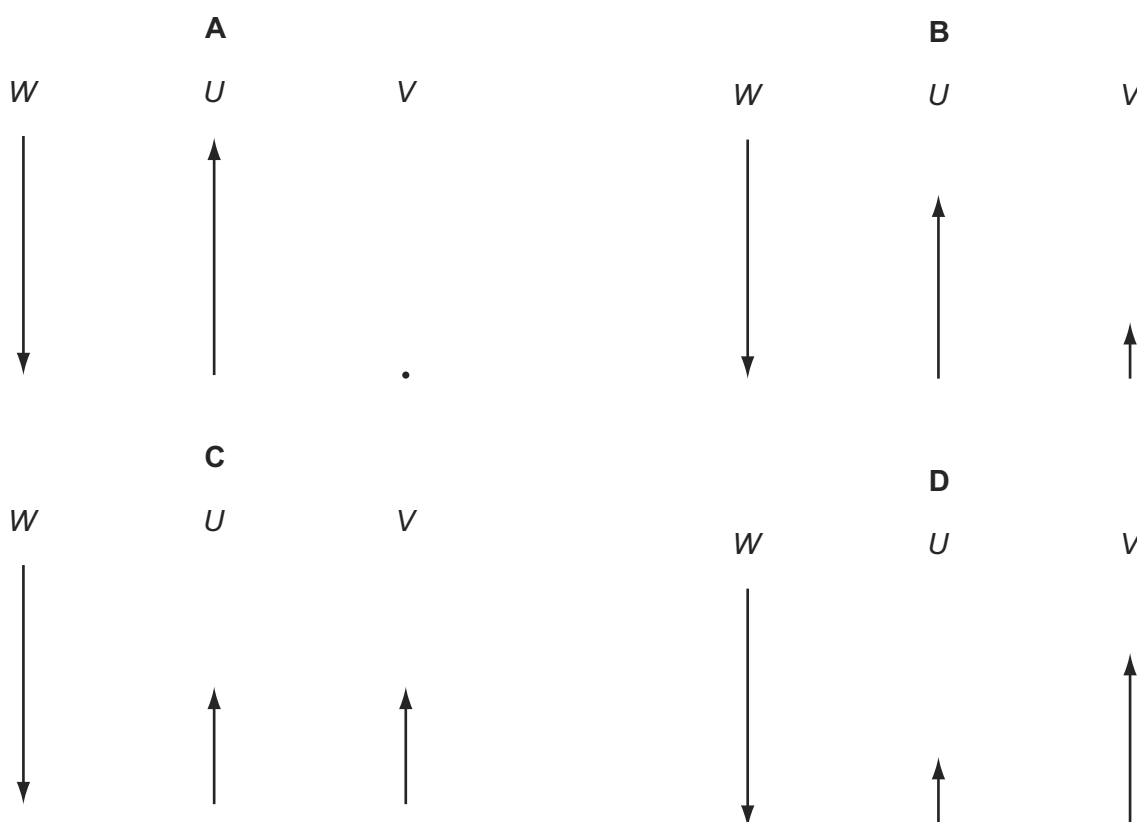


- 108 A hailstone, initially stationary at the base of a cloud, falls vertically towards the Earth. The diagram shows the magnitudes and directions of the forces acting on the hailstone as it starts to drop.

9702/13/O/N/12/Q15



Which diagram shows the magnitudes and directions of these forces when the hailstone attains a terminal (constant) speed in the air (of uniform density)?



- 109 A car travelling with speed 28 m s^{-1} leaves a motorway on an exit road. The end of the exit road is 22 m higher than the motorway.

9702/13/O/N/12/Q18

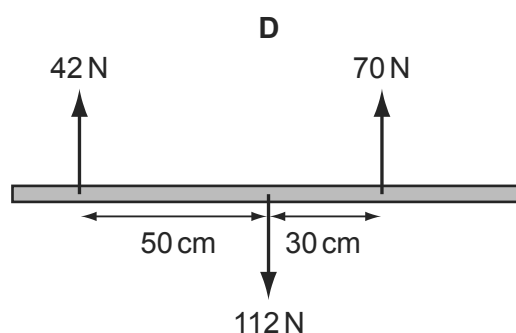
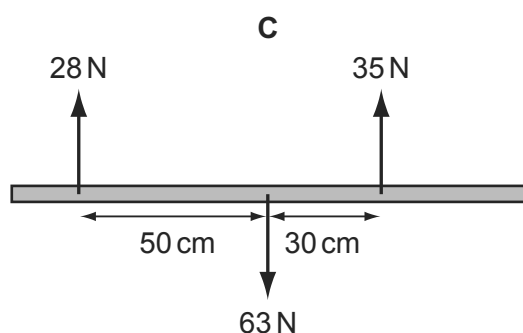
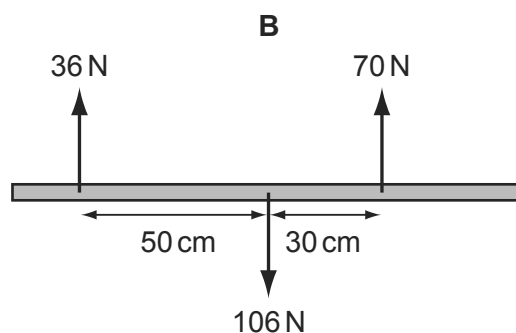
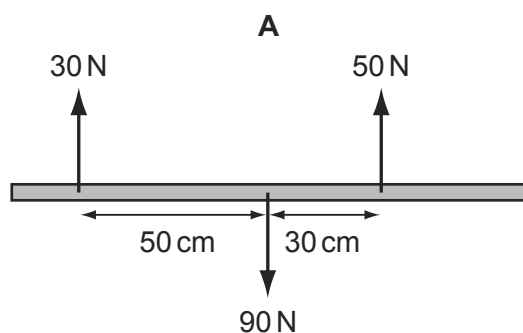
If only the force of gravity is considered, what will be the speed of the car at the end of the exit road?

- A** 7.3 m s^{-1} **B** 19 m s^{-1} **C** 21 m s^{-1} **D** 24 m s^{-1}

110 Four beams of the same length each have three forces acting on them.

9702/13/O/N/12/Q16

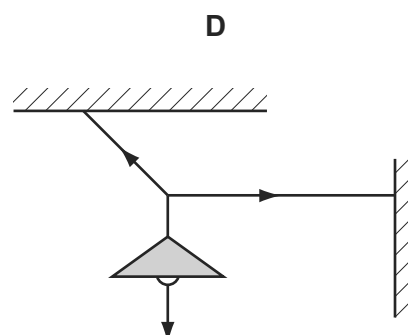
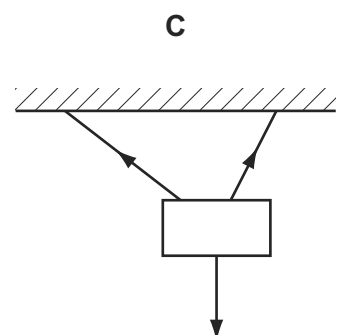
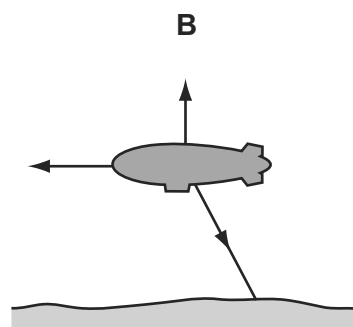
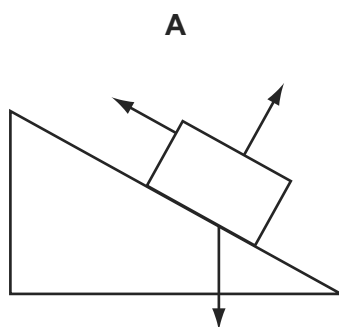
Which beam has both zero resultant force and zero resultant torque acting?



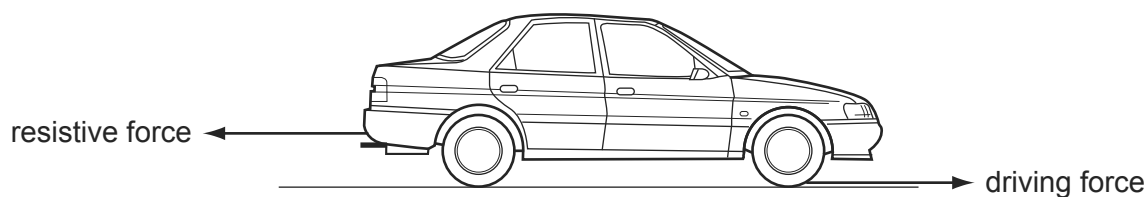
111 The diagrams show the forces acting on different bodies.

9702/13/O/N/12/Q17

Which body **cannot** be in equilibrium?

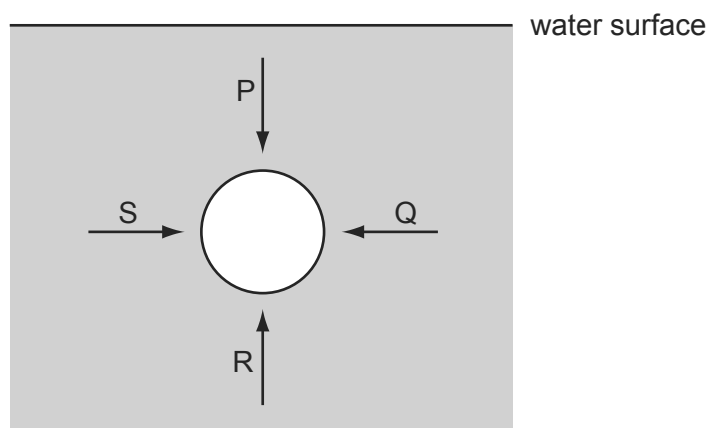


- 112 A car of mass 750 kg has a horizontal driving force of 2.0 kN acting on it. It has a forward horizontal acceleration of 2.0 m s^{-2} . 9702/11/M/J/13/Q12



What is the resistive force acting horizontally?

- A** 0.50 kN **B** 1.5 kN **C** 2.0 kN **D** 3.5 kN
- 113 The diagram represents a sphere under water. P, Q, R and S are forces acting on the sphere, due to the pressure of the water. 9702/11/M/J/13/Q15



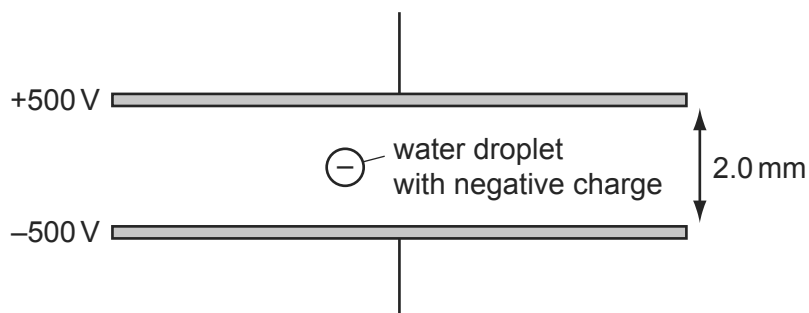
Each force acts perpendicularly to the sphere's surface. P and R act in opposite directions vertically. Q and S act in opposite directions horizontally.

Which information about the magnitudes of the forces is correct?

- A** $P < R$ and $S = Q$
B $P > R$ and $S = Q$
C $P = R$ and $S = Q$ and $P \neq S$
D $P = R$ and $S = Q$ and $P = S$

- 114 A small water droplet of mass $3.0\ \mu\text{g}$ carries a charge of $-6.0 \times 10^{-11}\text{ C}$. The droplet is situated in the Earth's gravitational field between two horizontal metal plates. The potential of the upper plate is $+500\text{ V}$ and the potential of the lower plate is -500 V .

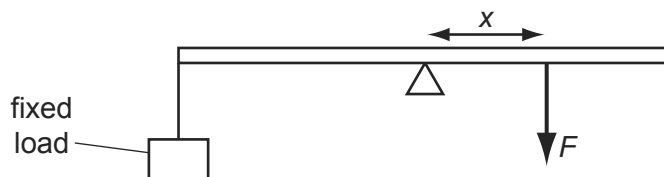
9702/11/M/J/13/Q13



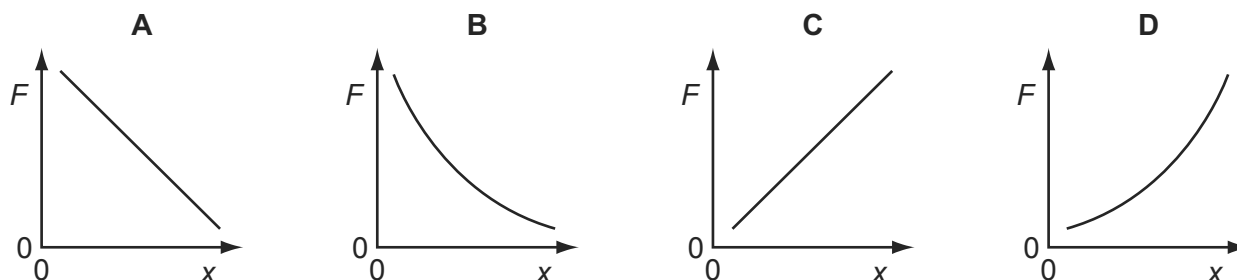
What is the motion of the droplet?

- A** It accelerates downwards.
 - B** It remains stationary.
 - C** It accelerates upwards.
 - D** It moves upwards at a constant velocity.
- 115 A horizontal bar is supported on a pivot at its centre of gravity. A fixed load is attached to one end of the bar. To keep the bar in equilibrium, a force F is applied at a distance x from the pivot.

9702/11/M/J/13/Q14



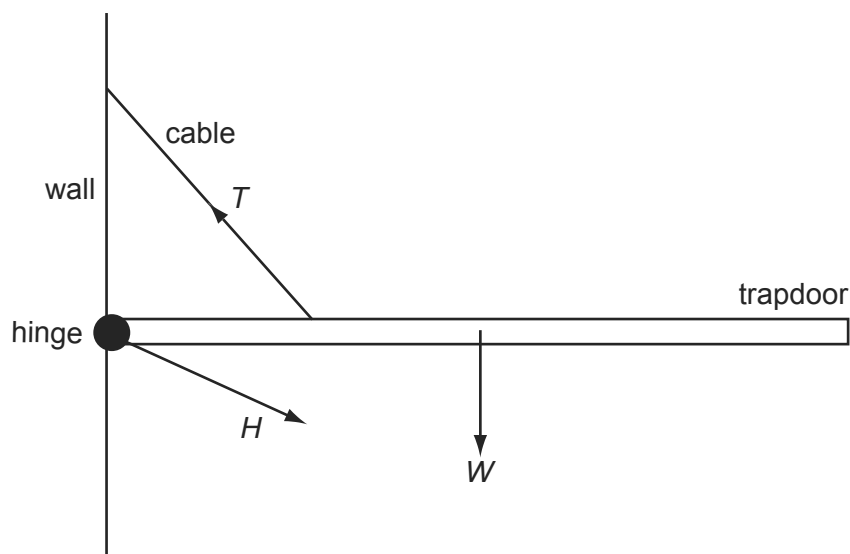
How does F vary with x ?



116 A hinged trapdoor is held closed in the horizontal position by a cable.

9702/11/M/J/13/Q16

Three forces act on the trapdoor: the weight W of the door, the tension T in the cable and the force H at the hinge.



Which list gives the three forces in **increasing** order of magnitude?

A H, T, W

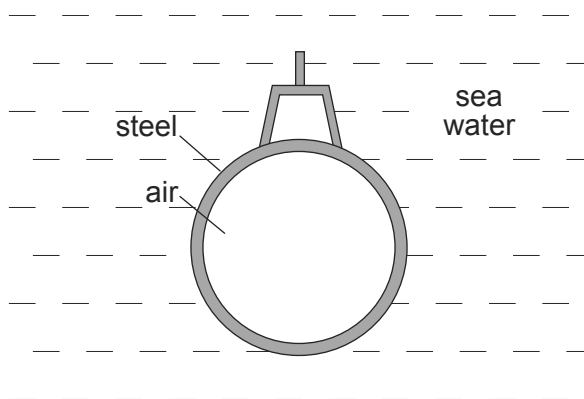
B T, H, W

C W, H, T

D W, T, H

117 A submarine is in equilibrium in a fully submerged position.

9702/12/M/J/13/Q11



What causes the upthrust on the submarine?

A The air in the submarine is less dense than sea water.

B The sea water exerts a greater upward force on the submarine than the weight of the steel.

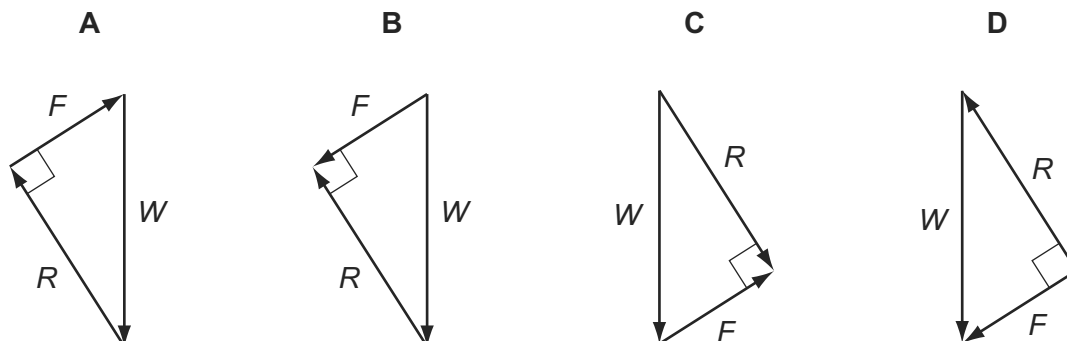
C The submarine displaces its own volume of sea water.

D There is a difference in water pressure acting on the top and on the bottom of the submarine.

- 118 A vehicle is at rest on a slope. It is considered to have three forces acting on it to keep it in equilibrium. 9702/12/M/J/13/Q12

They are its weight W , a normal reaction force R and a frictional force F .

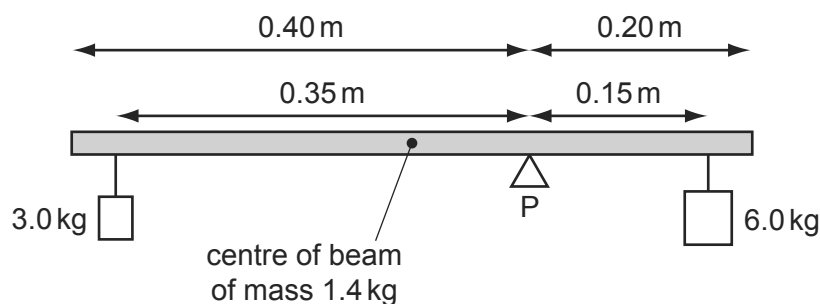
Which triangle of forces is correct?



- 119 All external forces on a body cancel out. 9702/12/M/J/13/Q13

Which statement **must** be correct?

- A The body does not move.
 - B The momentum of the body remains unchanged.
 - C The speed of the body remains unchanged.
 - D The total energy (kinetic and potential) of the body remains unchanged.
- 120 A uniform beam of mass 1.4 kg is pivoted at P as shown. The beam has a length of 0.60 m and P is 0.20 m from one end. Loads of 3.0 kg and 6.0 kg are suspended 0.35 m and 0.15 m from the pivot as shown. 9702/12/M/J/13/Q14

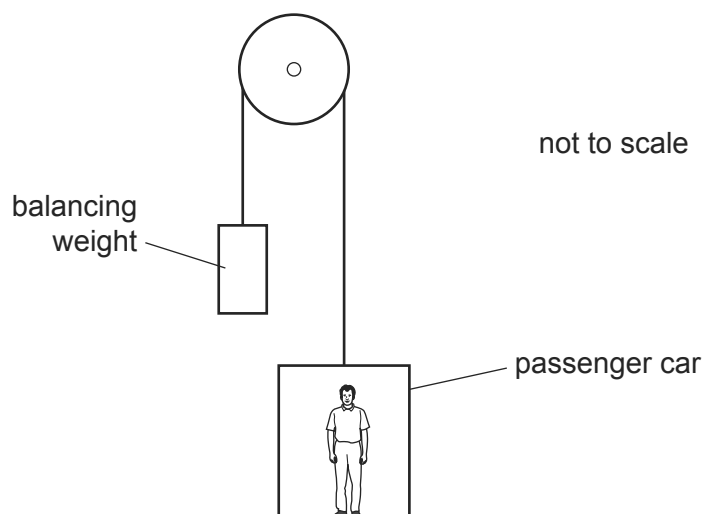


What torque must be applied to the beam in order to maintain it in equilibrium?

- A 0.010 Nm
- B 0.10 Nm
- C 0.29 Nm
- D 2.8 Nm

- 121 A lift (elevator) consists of a passenger car supported by a cable which runs over a light, frictionless pulley to a balancing weight. The balancing weight falls as the passenger car rises.

9702/13/M/J/13/Q9



Some masses are shown in the table.

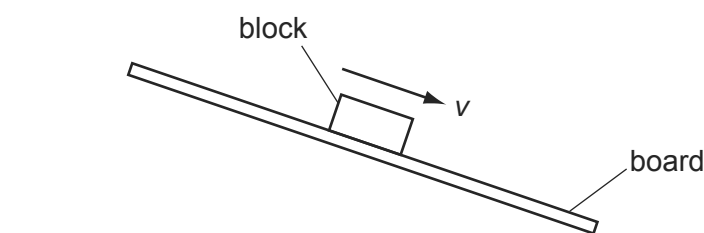
	mass / kg
passenger car	520
balancing weight	640
passenger	80

What is the magnitude of the acceleration of the car when carrying just one passenger and when the pulley is free to rotate?

- A** 0.032 ms^{-2} **B** 0.32 ms^{-2} **C** 0.61 ms^{-2} **D** 0.65 ms^{-2}

- 122 A wooden block rests on a rough board. The end of the board is then raised until the block slides down the plane of the board at constant velocity v .

9702/13/M/J/13/Q13

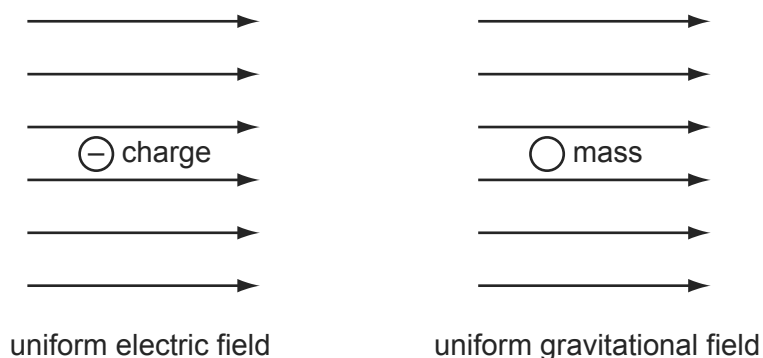


Which row describes the forces acting on the block when sliding with constant velocity?

	frictional force on block	resultant force on block
A	down the plane	down the plane
B	down the plane	zero
C	up the plane	down the plane
D	up the plane	zero

- 123 The diagrams show a negative electric charge situated in a uniform electric field and a mass situated in a uniform gravitational field.

9702/13/M/J/13/Q12

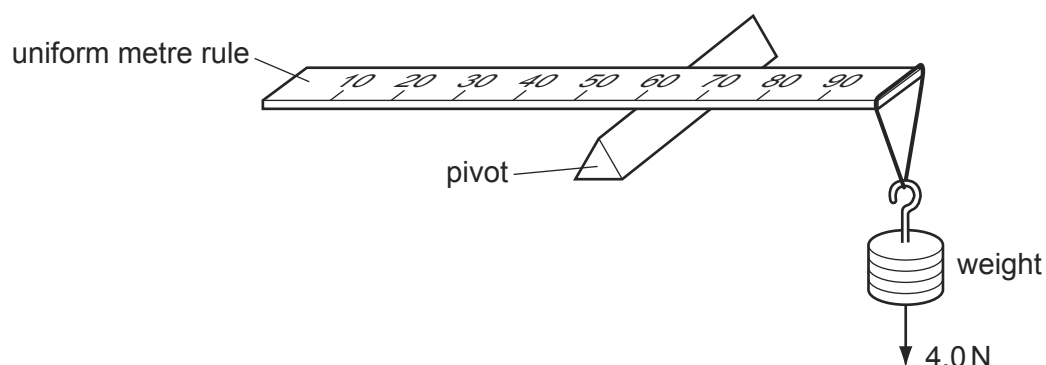


Which row shows the directions of the forces acting on the charge and on the mass?

	charge	mass
A		
B		
C		
D		

- 124 A uniform metre rule of weight 2.0 N is pivoted at the 60 cm mark. A 4.0 N weight is suspended from one end, causing the rule to rotate about the pivot.

9702/11/O/N/13/Q15



At the instant when the rule is horizontal, what is the resultant turning moment about the pivot?

- A** zero **B** 1.4 N m **C** 1.6 N m **D** 1.8 N m

- 125 An astronaut of mass m in a spacecraft experiences a gravitational force $F = mg$ when stationary on the launchpad.

9702/11/O/N/13/Q10

What is the gravitational force on the astronaut when the spacecraft is launched vertically upwards with an acceleration of $0.2g$?

- A** $1.2mg$ **B** mg **C** $0.8mg$ **D** 0

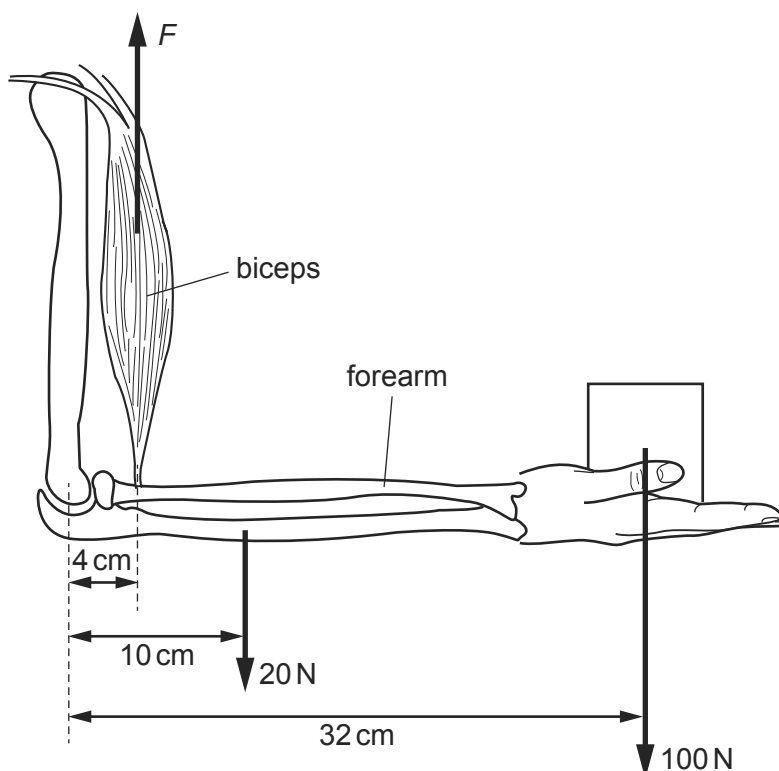
- 126 What is meant by the mass and by the weight of an object on the Earth?

9702/11/O/N/13/Q9

	mass	weight
A	its momentum divided by its velocity	the work done in lifting it one metre
B	the gravitational force on it	the property that resists its acceleration
C	the pull of the Earth on it	its mass divided by the acceleration of free fall
D	the property that resists its acceleration	the pull of the Earth on it

- 127 A man holds a 100 N load stationary in his hand. The combined weight of the forearm and hand is 20 N. The forearm is held horizontal, as shown.

9702/11/M/J/14/Q12



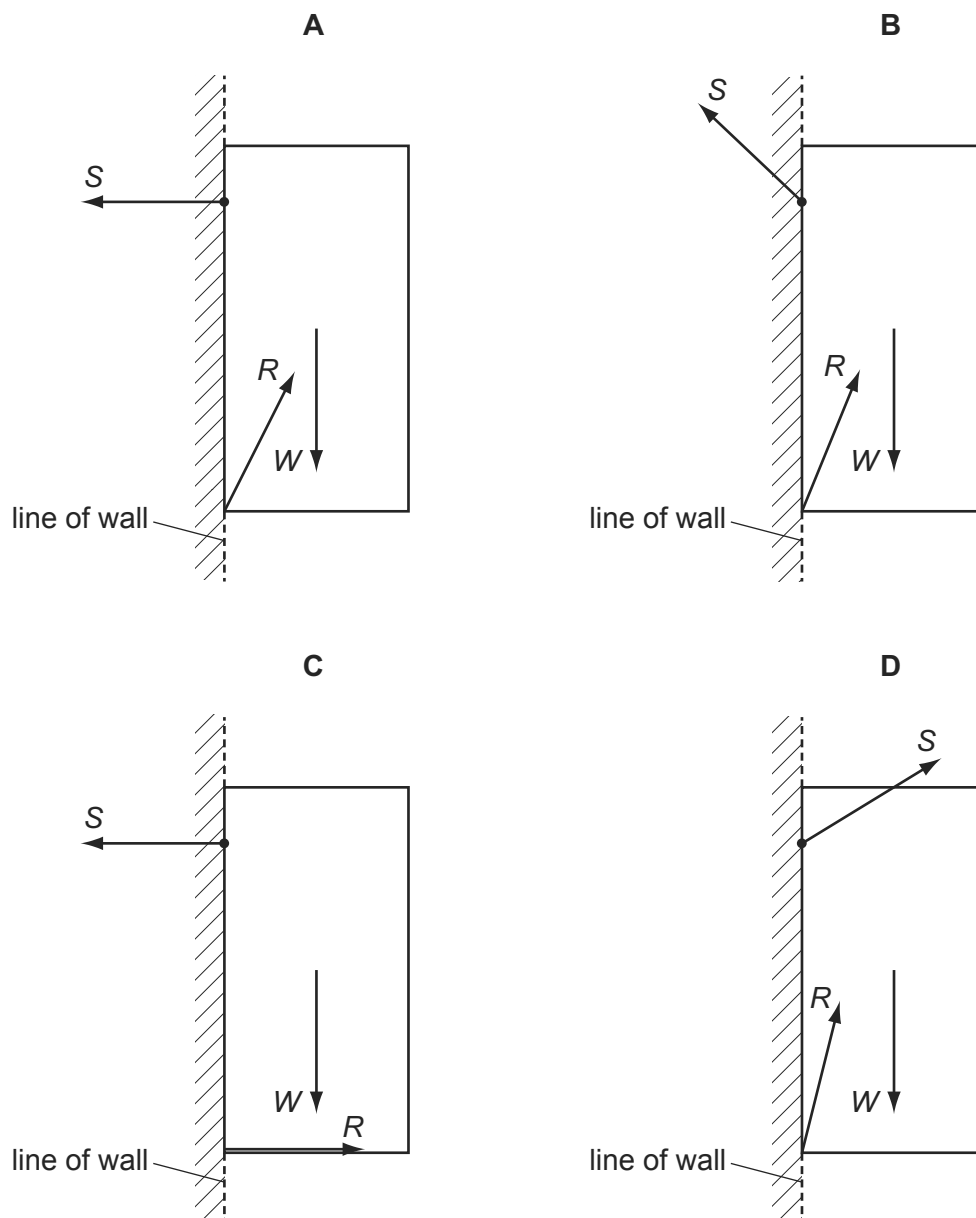
What is the vertical force F needed in the biceps?

- A** 750 N **B** 800 N **C** 850 N **D** 900 N

128 A cupboard is attached to a wall by a screw.

9702/13/O/N/13/Q14

Which force diagram shows the cupboard in equilibrium, with the weight W of the cupboard, the force S that the screw exerts on the cupboard and the force R that the wall exerts on the cupboard?



129 The diagrams show two ways of hanging the same picture.

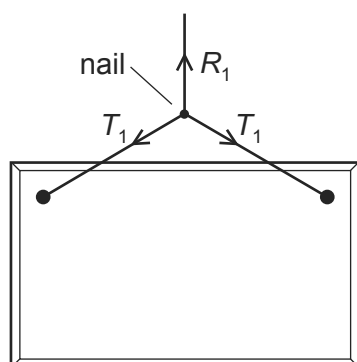


diagram 1

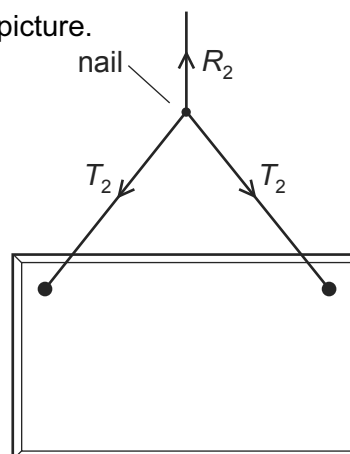


diagram 2

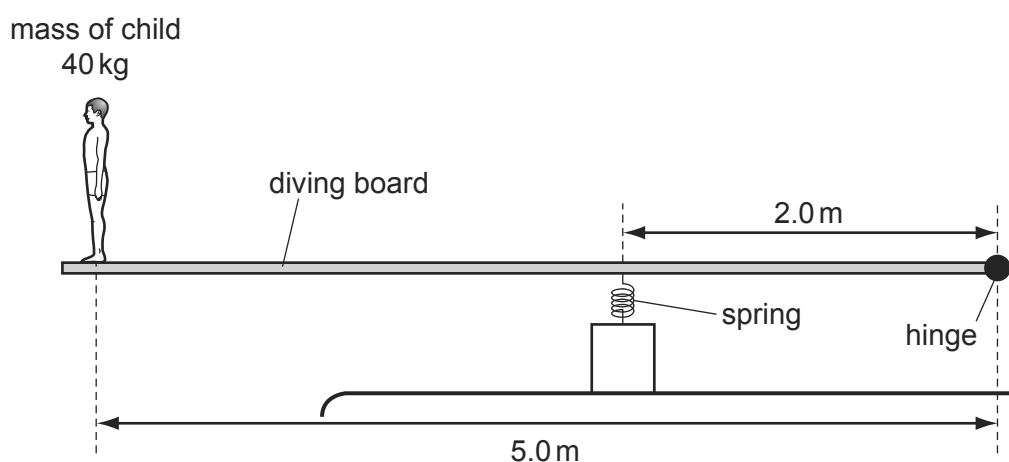
In both cases, a string is attached to the same points on the picture and looped symmetrically over a nail in a wall. The forces shown are those that act on the nail.

In diagram 1, the string loop is shorter than in diagram 2.

Which information about the magnitude of the forces is correct?

- A** $R_1 = R_2$ $T_1 = T_2$
- B** $R_1 = R_2$ $T_1 > T_2$
- C** $R_1 > R_2$ $T_1 < T_2$
- D** $R_1 < R_2$ $T_1 = T_2$

130 A diving board of length 5.0 m is hinged at one end and supported 2.0 m from this end by a spring of spring constant 10 kN m^{-1} . A child of mass 40 kg stands at the far end of the board. 9702/13/O/N/13/Q15

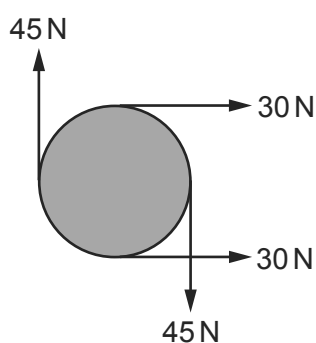


What is the extra compression of the spring caused by the child standing on the end of the board?

- A** 1.0 cm **B** 1.6 cm **C** 9.8 cm **D** 16 cm

131 The diagram shows four forces applied to a circular object.

9702/12/M/J/14/Q13

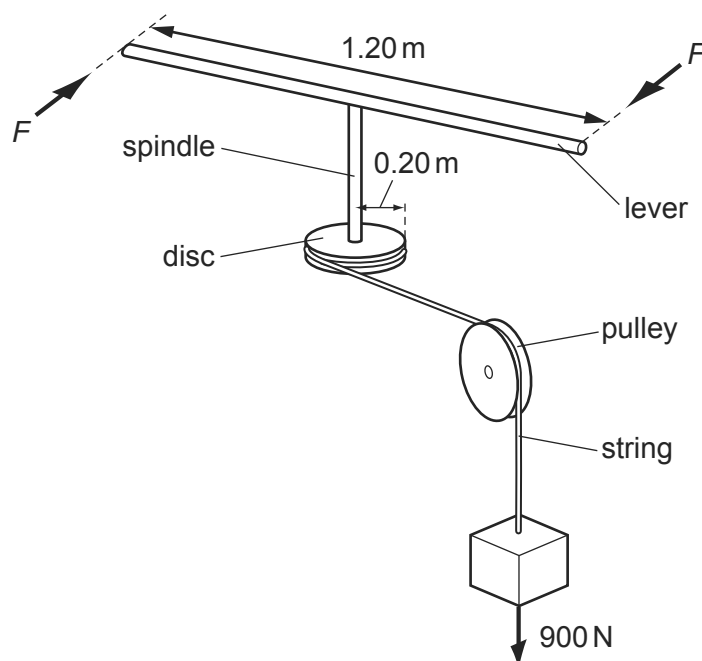


Which of the following describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
A	non-zero	non-zero
B	non-zero	zero
C	zero	non-zero
D	zero	zero

132 A spindle is attached at one end to the centre of a lever of length 1.20 m and at its other end to the centre of a disc of radius 0.20 m. A string is wrapped round the disc, passes over a pulley and is attached to a 900 N weight.

9702/11/M/J/14/Q13

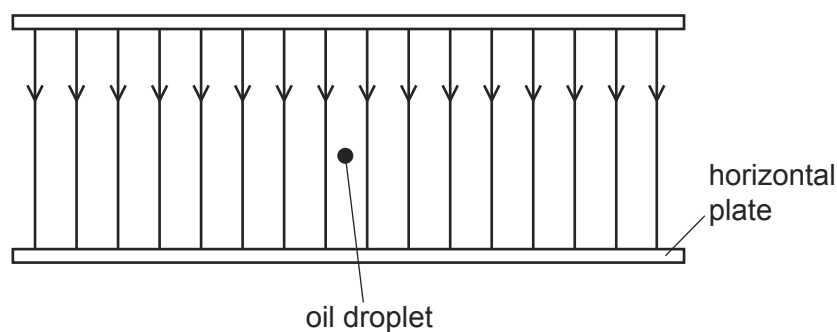


What is the minimum force F , applied to each end of the lever, that could lift the weight?

- A** 75 N **B** 150 N **C** 300 N **D** 950 N

- 133 A tiny oil droplet with mass $6.9 \times 10^{-13} \text{ kg}$ is at rest in an electric field of electric field strength $2.1 \times 10^7 \text{ NC}^{-1}$, as shown.

9702/12/M/J/14/Q12



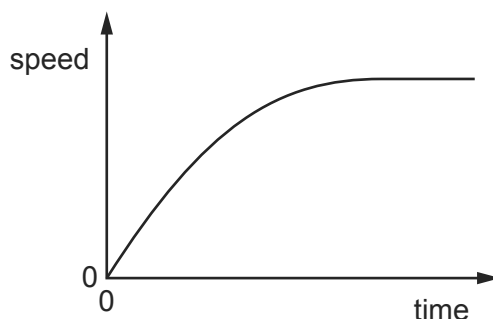
The weight of the droplet is exactly balanced by the electrical force on the droplet.

What is the charge on the droplet?

- A** $3.3 \times 10^{-20} \text{ C}$
- B** $-3.3 \times 10^{-20} \text{ C}$
- C** $3.2 \times 10^{-19} \text{ C}$
- D** $-3.2 \times 10^{-19} \text{ C}$

- 134 The graph shows the variation with time of the speed of a raindrop falling vertically through air.

9702/12/M/J/14/Q11



Which statement is correct?

- A** The acceleration decreases to produce a steady speed.
- B** The acceleration increases as the speed increases.
- C** The air resistance decreases as the speed increases.
- D** The resultant force increases as the speed increases.

135 What is the condition for an object to be in equilibrium?

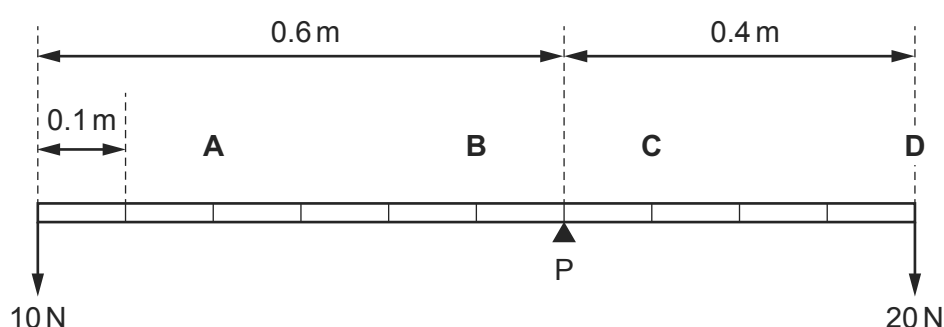
- A** The object's velocity and the resultant torque on it must both be zero.
- B** The object's velocity must be zero.
- C** The resultant force and the resultant torque on the object must both be zero.
- D** The resultant force on the object must be zero.

136 A uniform beam is pivoted at P as shown. Weights of 10 N and 20 N are attached to its ends.

The length of the beam is marked at 0.1 m intervals. The weight of the beam is 100 N.

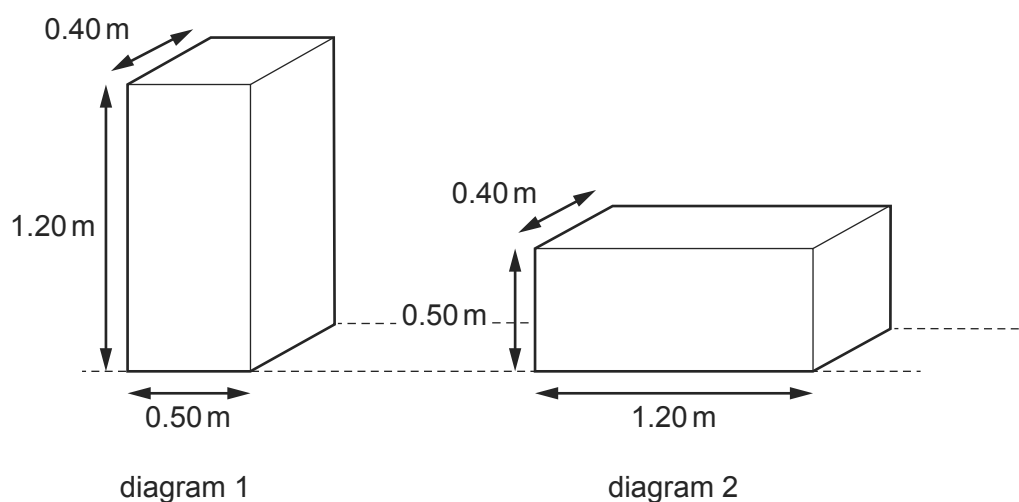
At which point should a further weight of 20 N be attached to achieve equilibrium?

9702/13/M/J/14/Q15



137 A uniform solid cuboid of concrete of dimensions $0.50\text{ m} \times 1.20\text{ m} \times 0.40\text{ m}$ and weight 4000 N rests on a flat surface with the 1.20 m edge vertical as shown in diagram 1.

9702/13/M/J/14/Q14



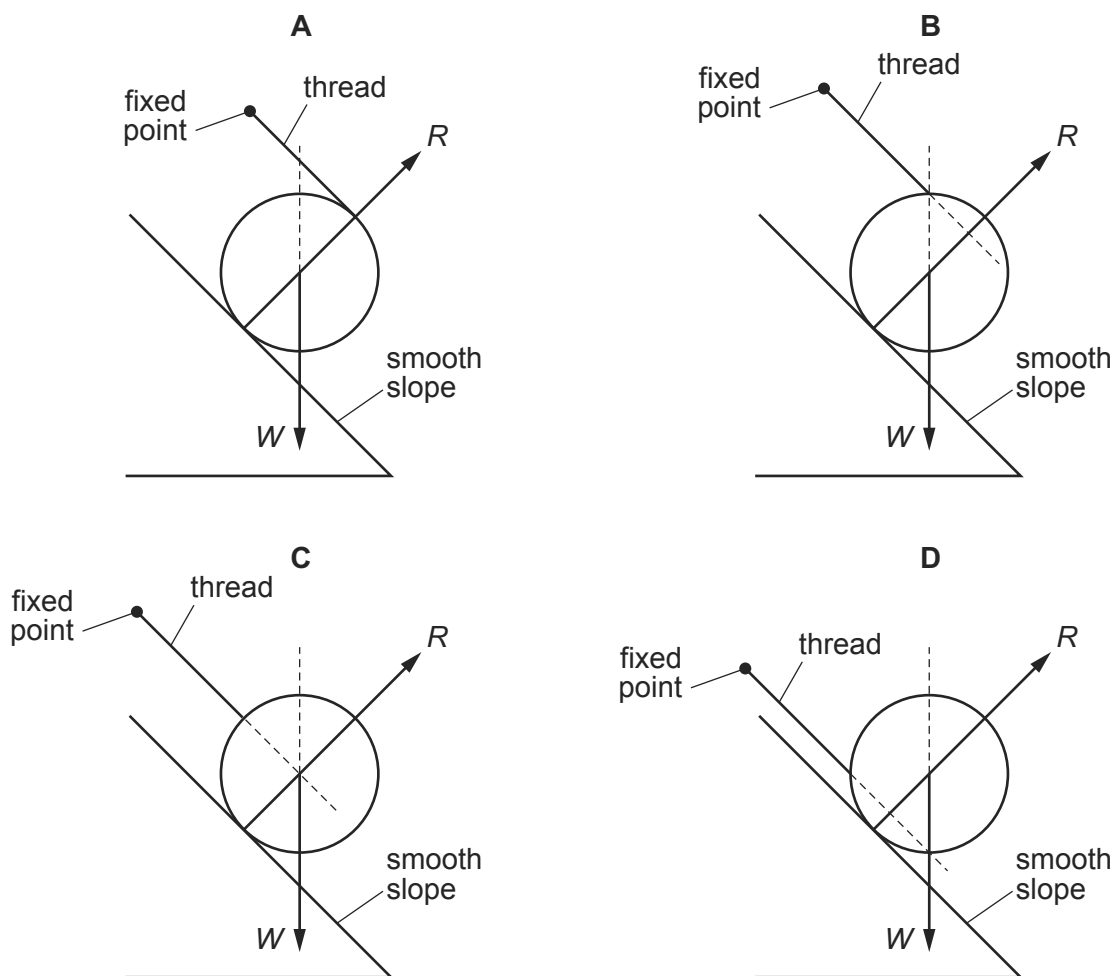
What is the minimum energy required to roll the cuboid through 90° to the position shown in diagram 2 with the 0.50 m edge vertical?

- A** 200 J
- B** 400 J
- C** 1400 J
- D** 2600 J

- 138 A cylinder of weight W is placed on a smooth slope. The contact force of the slope on the cylinder is R . A thread is attached to the surface of the cylinder. The other end of the thread is fixed.

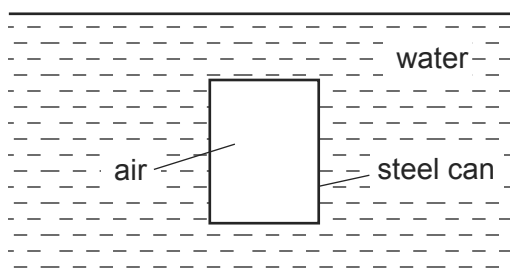
9702/13/O/N/14/Q13

Which diagram shows the cylinder in equilibrium?



- 139 A sealed cylindrical steel can is situated below the surface of water.

9702/13/O/N/14/Q12

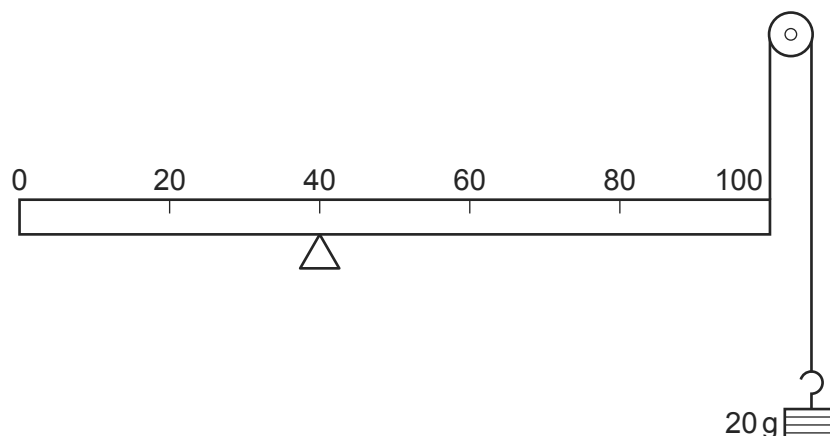


What is the origin of the upthrust that acts on the can?

- A The air pressure in the can is less than the water pressure outside the can.
- B The average density of the air and steel is less than the density of water.
- C The water pressure on the bottom of the can is greater than the water pressure on the top.
- D The weight of displaced water acts upwards on the can.

- 140 A uniform metre rule of mass 100 g is supported by a pivot at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram.

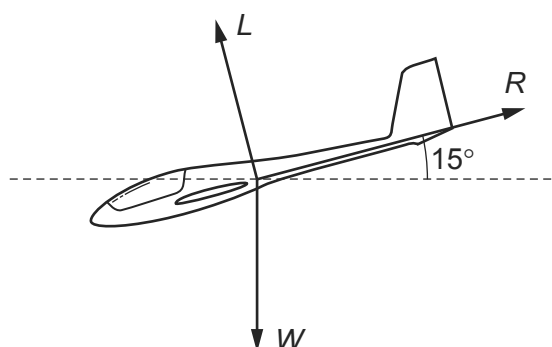
9702/13/O/N/14/Q14



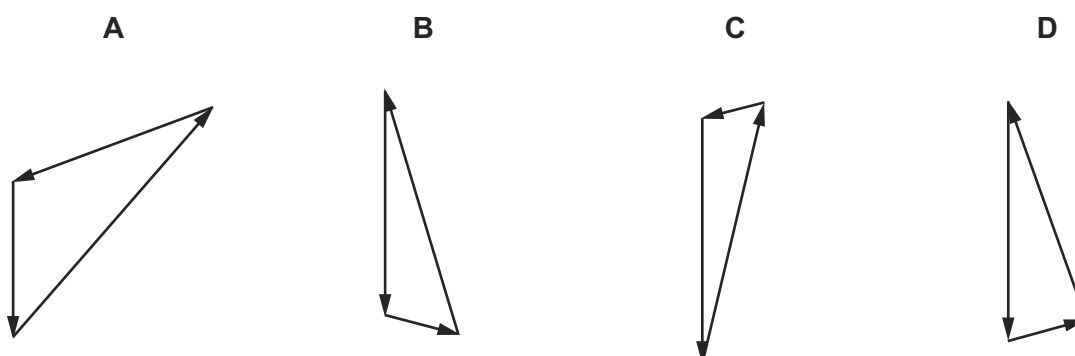
At which mark on the rule must a 50 g mass be suspended so that the rule balances?

- 141 A glider is descending at constant speed at an angle of 15° to the horizontal. The diagram shows the directions of the lift L , air resistance R and weight W acting on the glider.

9702/11/O/N/14/Q10



Which vector triangle could represent the forces acting on the glider?



- 142 A ball is falling at terminal speed in still air. The forces acting on the ball are upthrust, viscous drag and weight.

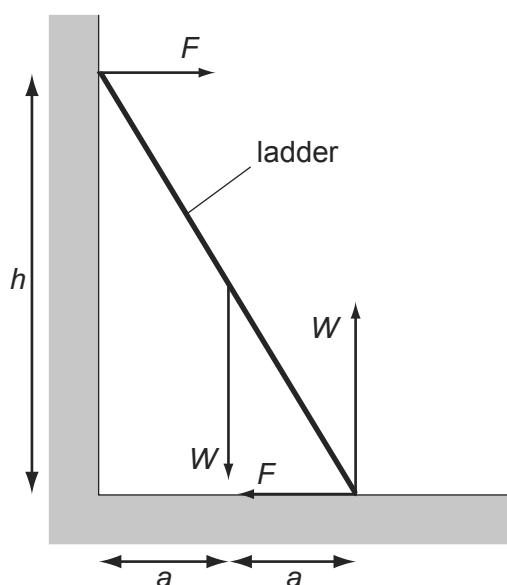
9702/11/O/N/14/Q11

What is the order of increasing magnitude of these three forces?

- A** upthrust $\rightarrow$ viscous drag $\rightarrow$ weight
B viscous drag $\rightarrow$ upthrust $\rightarrow$ weight
C viscous drag $\rightarrow$ weight $\rightarrow$ upthrust
D weight $\rightarrow$ upthrust $\rightarrow$ viscous drag
- 143 A uniform ladder rests against a vertical wall where there is negligible friction. The bottom of the ladder rests on rough ground where there is friction. The top of the ladder is at a height h above the ground and the foot of the ladder is at a distance $2a$ from the wall.

9702/11/O/N/14/Q12

The diagram shows the forces that act on the ladder.

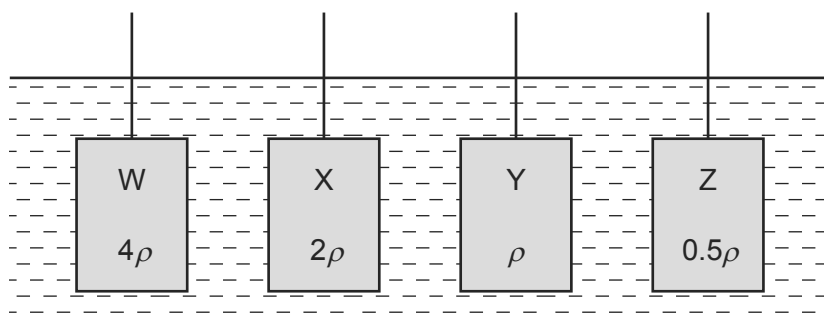


Which equation is formed by taking moments?

- A** $Wa + Fh = 2Wa$
B $Fa + Wa = Fh$
C $Wa + 2Wa = Fh$
D $Wa - 2Wa = 2Fh$

- 144 Four cuboids with identical length, breadth and height are immersed in water. The cuboids are held at the same depth and in identical orientations by vertical rods, as shown.

9702/13/M/J/15/Q14



Water has density ρ .

Cuboid W is made of material of density 4ρ .

Cuboid X is made of material of density 2ρ .

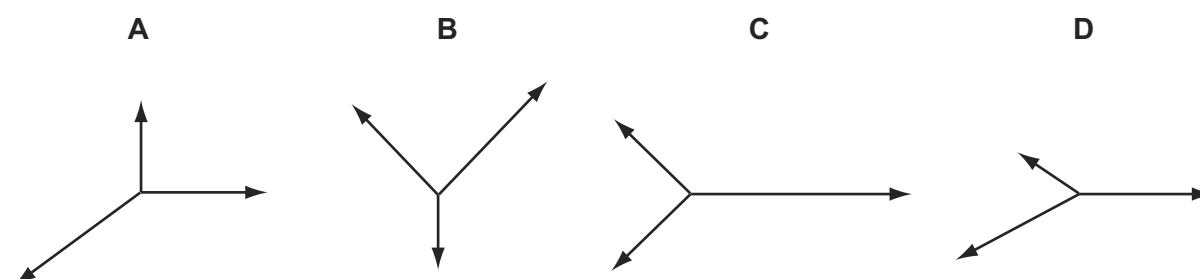
Cuboid Y is made of material of density ρ .

Cuboid Z is made of material of density 0.5ρ .

Which statement is correct?

- A** The upthrust of the water on each of the cuboids is the same.
B The upthrust of the water on W is twice the upthrust of the water on X.
C The upthrust of the water on X is twice the upthrust of the water on W.
D The upthrust of the water on Y is zero.
- 145 The diagrams represent systems of coplanar forces acting at a point. The lengths of the force vectors represent the magnitudes of the forces.

9702/13/M/J/15/Q16



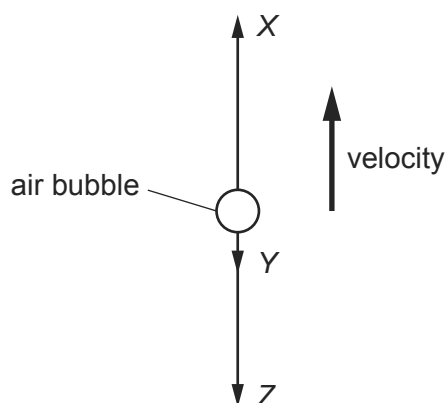
- 146 What is a reasonable estimate of the average gravitational force acting on a fully grown woman standing on the Earth?

9702/11/M/J/15/Q10

- A** 60 N **B** 250 N **C** 350 N **D** 650 N

- 147 An air bubble in a tank of water is rising with constant velocity. The forces acting on the bubble are X , Y and Z as shown.

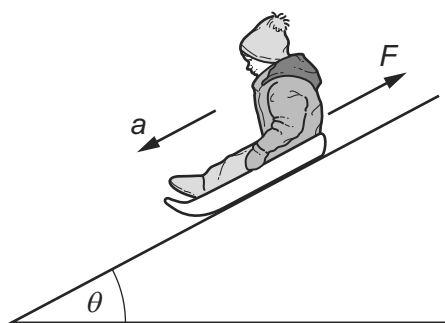
9702/13/M/J/15/Q15



What describes the three forces?

- A** Z is the viscous drag on the bubble, Y is the weight of the bubble, X is the upthrust on the bubble and $X = Y + Z$.
- B** Z is the viscous drag on the bubble, Y is the weight of the bubble, X is the upthrust on the bubble and $X > Y + Z$.
- C** Z is the weight of the bubble, Y is the viscous drag on the bubble, X is the upthrust on the bubble and $X = Y + Z$.
- D** Z is the weight of the bubble, Y is the viscous drag on the bubble, X is the upthrust on the bubble and $X > Y + Z$.
- 148 A child on a sledge slides down a hill with acceleration a . The hill makes an angle θ with the horizontal.

9702/11/M/J/15/Q12



The total mass of the child and the sledge is m . The acceleration of free fall is g .

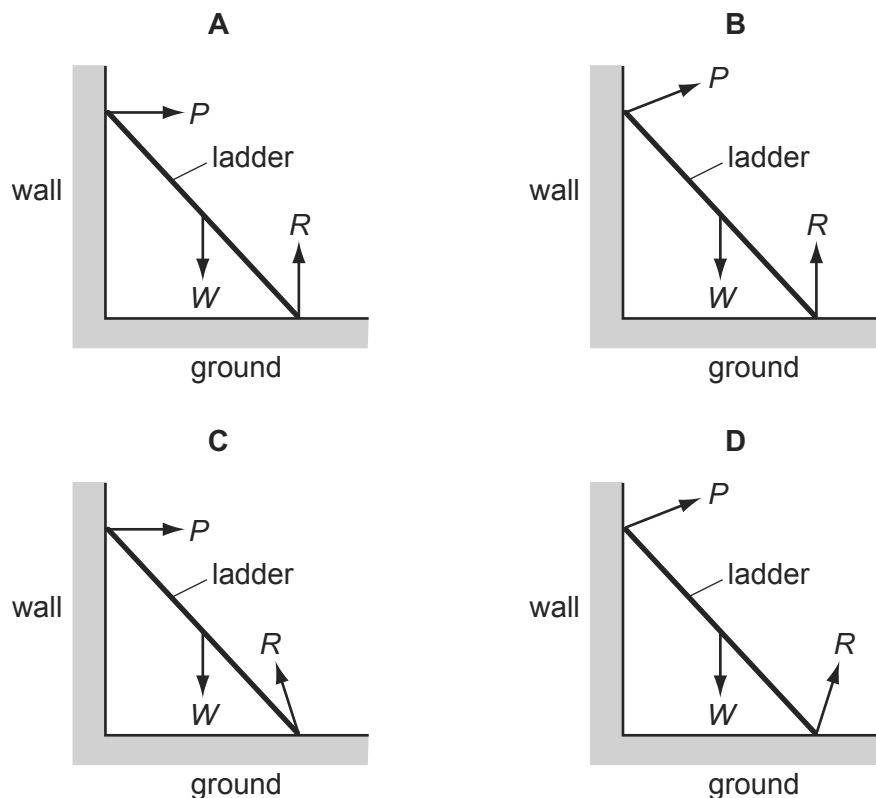
What is the friction force F ?

- A** $m(g \cos \theta - a)$
- B** $m(g \cos \theta + a)$
- C** $m(g \sin \theta - a)$
- D** $m(g \sin \theta + a)$

- 149 A ladder is positioned on icy (frictionless) ground and is leant against a rough wall. At the instant of release it begins to slide.

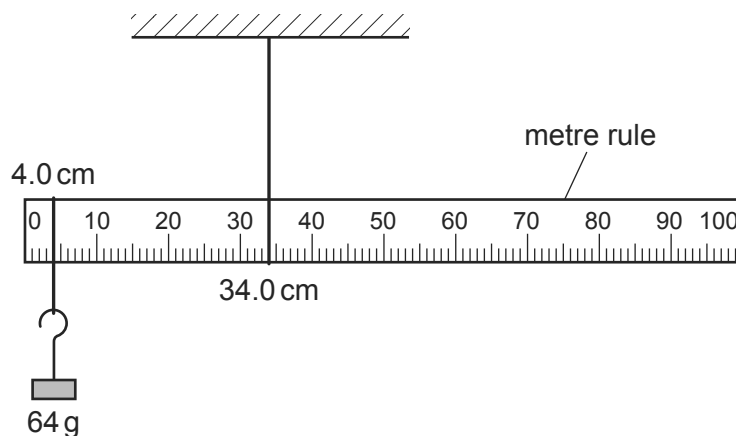
9702/12/M/J/15/Q14

Which diagram correctly shows the directions of the forces P , W and R acting on the ladder as it slides?



- 150 A uniform metre rule is pivoted at the 34.0 cm mark, as shown.

9702/11/M/J/15/Q15



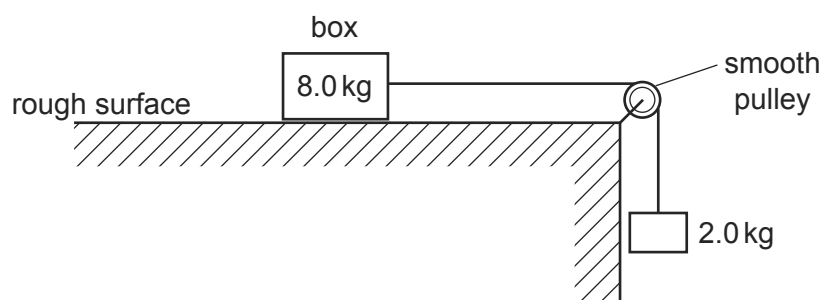
The rule balances when a 64 g mass is hung from the 4.0 cm mark.

What is the mass of the metre rule?

- A** 38 g **B** 44 g **C** 120 g **D** 136 g

- 151 A box of mass 8.0 kg rests on a horizontal rough surface. A string attached to the box passes over a smooth pulley and supports a 2.0 kg mass at its other end.

9702/11/M/J/15/Q13



When the box is released, a frictional force of 6.0 N acts on it.

What is the acceleration of the box?

- A** 1.4 ms^{-2} **B** 1.7 ms^{-2} **C** 2.0 ms^{-2} **D** 2.6 ms^{-2}

FORCES

Q.No	Key
1	B
2	D
3	C
4	A
5	C
6	A
7	A
8	C
9	B
10	D
11	B
12	C
13	A
14	C
15	C
16	B
17	B
18	B
19	C
20	B
21	A
22	B
23	C
24	C
25	A
26	D
27	A
28	B
29	D
30	B
31	D
32	B
33	A
34	A
35	B
36	C
37	C

38	B
39	C
40	D
41	A
42	A
43	A
44	-
45	D
46	A
47	D
48	B
49	D
50	A
51	A
52	B
53	C
54	B
55	C
56	C
57	B
58	C
59	C
60	C
61	A
62	B
63	D
64	B
65	C
66	C
67	D
68	D
69	A
70	B
71	C
72	A
73	C
74	B
75	C

76	D
77	C
78	B
79	D
80	C
81	C
82	B
83	D
84	C
85	C
86	A
87	C
88	A
89	D
90	D
91	A
92	B
93	D
94	B
95	D
96	D
97	B
98	D
99	C
100	D
101	B
102	C
103	C
104	D
105	B
106	B
107	C
108	D
109	B
110	D
111	A
112	A
113	A

114	C
115	B
116	C
117	D
118	A
119	B
120	D
121	B
122	D
123	B
124	B
125	B
126	D
127	C
128	B
129	B
130	C
131	A
132	B
133	D
134	A
135	C
136	D
137	A
138	C
139	C
140	C
141	D
142	A
143	A
144	A
145	A
146	D
147	A
148	C
149	B
150	C
151	A

Q1.

- 2 The Brownian motion of smoke particles in air may be observed using the apparatus shown in Fig. 2.1.

For
Examiner
Use

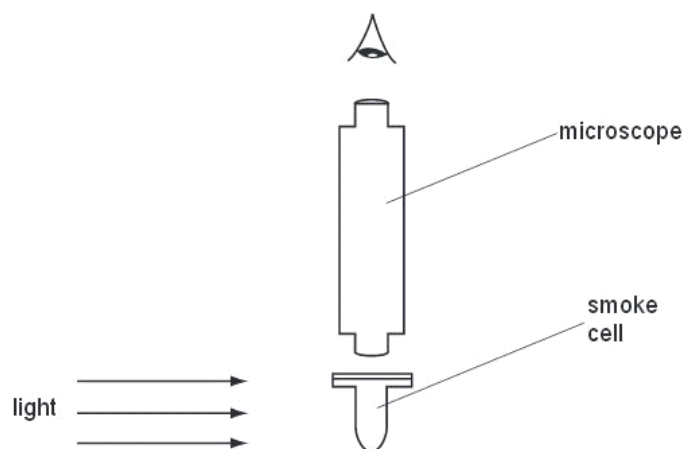


Fig. 2.1

- (a)** Describe what is seen when viewing a smoke particle through the microscope.

.....

[2]

- (b)** Suggest and explain what difference, if any, would be observed in the movement of smoke particles when larger smoke particles than those observed in **(a)** are viewed through the microscope.

.....

[2]

Q2.

- 3 **(a)** Explain what is meant by the *internal energy* of a substance.

For
Examiner
Use

.....

 [2]

(b) State and explain, in molecular terms, whether the internal energy of the following increases, decreases or does not change.

(i) a lump of iron as it is cooled

.....
.....
.....
..... [3]

(ii) some water as it evaporates at constant temperature

.....
.....
.....
..... [3]

Q3.

4 (a) Define *density*.

.....
.....
..... [1]

- (b) A U-tube contains some mercury. Water is poured into one arm of the U-tube and oil is poured into the other arm, as shown in Fig. 4.1.

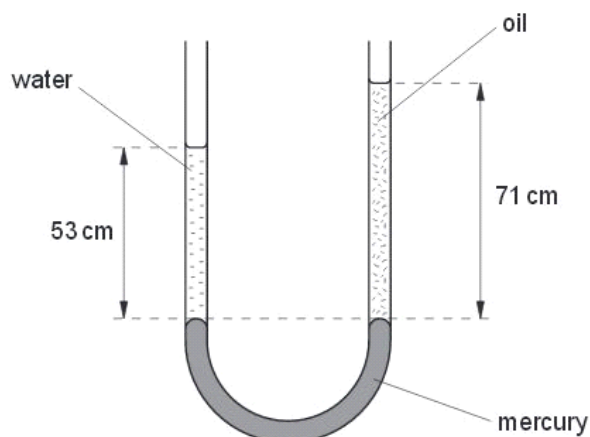


Fig. 4.1

The amounts of oil and water are adjusted until the surface of the mercury in the two arms is at the same horizontal level.

- (i) State how it is known that the pressure at the base of the column of water is the same as the pressure at the base of the column of oil.

.....
 [1]

- (ii) The column of water, density $1.0 \times 10^3 \text{ kg m}^{-3}$, is 53 cm high. The column of oil is 71 cm high.

Calculate the density of the oil. Explain your working.

density = ... kg m^{-3} [3]

Q4.

- 3 (a) Define *density*.

.....[1]

- (b) Liquid of density ρ fills a container to a depth h , as illustrated in Fig. 3.1.

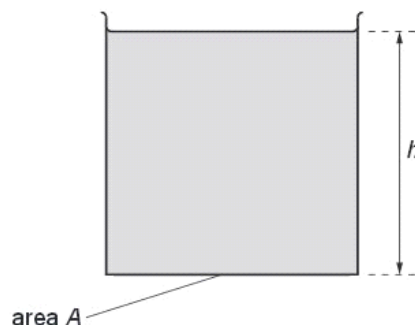


Fig. 3.1

The container has vertical sides and a base of area A .

- (i) State, in terms of A , h and ρ , the mass of liquid in the container.

.....[1]

- (ii) Hence derive an expression for the pressure p exerted by the liquid on the base of the container. Explain your working.

[2]

- (c) The density of liquid water is 1.0 g cm^{-3} . The density of water vapour at atmospheric pressure is approximately $\frac{1}{1600} \text{ g cm}^{-3}$.

Determine the ratio

- (i) $\frac{\text{volume of water vapour}}{\text{volume of equal mass of liquid water}}$,

ratio = ...[1]

- (ii) $\frac{\text{mean separation of molecules in water vapour}}{\text{mean separation of molecules in liquid water}}$.

ratio = ...[2]

- (d) State the evidence for

- (i) the molecules in solids and liquids having approximately the same separation,

.....
[1]

- (ii) strong rigid forces between molecules in solids.

strong:

rigid:[2]

Q5.

4 (a) State the evidence for the assumption that

(i) there are significant forces of attraction between molecules in the solid state,

.....
.....[1]

(ii) the forces of attraction between molecules in a gas are negligible.

.....
.....[1]

(b) Explain, on the basis of the kinetic model of gases, the pressure exerted by a gas.

.....
.....
.....
.....
.....[4]

(c) Liquid nitrogen has a density of 810kgm^{-3} . The density of nitrogen gas at room temperature and pressure is approximately 1.2kgm^{-3} . Suggest how these densities relate to the spacing of nitrogen molecules in the liquid and in the gaseous states.

.....
.....
.....[2]

Ex.

Q6.

- 6 (a) State two assumptions of the simple kinetic model of a gas.

For
Exam
Use

1.

.....

2.

.....

[2]

- (b) Use the kinetic model of gases and Newton's laws of motion to explain how a gas exerts a pressure on the sides of its container.

.....

.....

.....

.....

..... [3]

Q7.

- 7 (a) Explain the difference in densities in solids, liquids and gases using ideas of the spacing between molecules.

For
Exam
Use

.....

.....

.....

.....

.....

.....

..... [3]

- (b) A hydrogen nucleus (proton) may be assumed to be a sphere of radius 1×10^{-15} m. Calculate the density of a hydrogen nucleus.

density = ... kg m^{-3} [3]

- (c) The density of hydrogen gas in a pressurised cylinder is 4 kg m^{-3} . Suggest a reason why this density is much less than your answer in (b).

.....

 [1]

Q8.

- 3 (a) Show that the pressure P due to a liquid of density ρ is proportional to the depth h below the surface of the liquid.

Ex

[4]

- (b) The pressure of the air at the top of a mountain is less than that at the foot of the mountain. Explain why the difference in air pressure is not proportional to the difference in height as suggested by the relationship in (a).

.....

 [2]

Q9.

4 (a) Define *pressure*.

/
Ex
t

.....
..... [1]

(b) Use the kinetic model to explain the pressure exerted by a gas.

.....
.....
.....
.....
.....
..... [4]

(c) Explain whether the collisions between the molecules of an ideal gas are elastic or inelastic.

.....
.....
..... [2]

Q10.

- 4 (a) Describe apparatus that demonstrates Brownian motion. Include a diagram.

For
Examine
Use

.....
.....
.....
.....
.....[2]

- (b) Describe the observations made using the apparatus in (a).

.....
.....
.....[2]

- (c) State and explain two conclusions about the properties of molecules of a gas that follow from the observations in (b).

1.
.....
2.
.....[2]

Q11.

- 5 (a) Distinguish between the structure of a metal and of a polymer.

metal:

.....

.....

polymer:

.....

..... [4]

- (b) Latex is a natural form of rubber. It is a polymeric material.

- (i) Describe the properties of a sample of latex.

.....

.....

..... [2]

- (ii) The process of heating latex with a small amount of sulphur creates cross-links between molecules. Natural latex has very few cross-links between its molecules.

Suggest how this process changes the properties of latex.

.....

.....

..... [2]

Q12.

- 5 Some smoke particles are viewed through a microscope, as illustrated in Fig. 5.1.

Ext

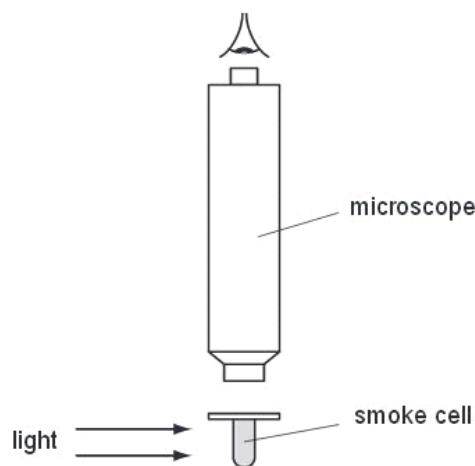


Fig. 5.1

Brownian motion is observed.

- (a) Explain what is meant by *Brownian motion*.

.....
.....
..... [2]

- (b) Suggest and explain why Brownian motion provides evidence for the movement of molecules as assumed in the kinetic theory of gases.

.....
.....
.....
..... [2]

- (c) Smoke from a poorly maintained engine contains large particles of soot. Suggest why the Brownian motion of such large particles is undetectable.

.....
.....
..... [2]

Q13.

- 2 (a) (i) State one **similarity** between the processes of evaporation and boiling.

.....
..... [1]

- (ii) State two **differences** between the processes of evaporation and boiling.

1.
.....
2.
..... [4]

- (b) Titanium metal has a density of 4.5 g cm^{-3} .

A cube of titanium of mass 48 g contains 6.0×10^{23} atoms.

- (i) Calculate the volume of the cube.

volume = ... cm^3 [1]

(ii) Estimate

E

1. the volume occupied by each atom in the cube,

volume = ... cm^3 [1]

2. the separation of the atoms in the cube.

separation = ... cm [1]

Q14.

- 2 Briefly describe the structures of crystalline solids, polymers and amorphous materials.

crystalline solids

.....

.....

polymers

.....

.....

amorphous materials

.....

.....

[5]

Q15.

- 1 (a) Define *density*.

.....

..... [1]

- (b) Explain how the difference in the densities of solids, liquids and gases may be related to the spacing of their molecules.

.....

.....

.....

..... [2]

(c) A paving slab has a mass of 68 kg and dimensions 50 mm × 600 mm × 900 mm.

- (i) Calculate the density, in kg m^{-3} , of the material from which the paving slab is made.

density = ... kg m^{-3} [2]

- (ii) Calculate the maximum pressure a slab could exert on the ground when resting on one of its surfaces.

pressure = ... Pa [3]

Q16.

- 3 (a) Define *pressure*.

.....
..... [1]

- (b) Explain, in terms of the air molecules, why the pressure at the top of a mountain is less than at sea level.

.....
.....
.....
.....
..... [3]

- (c) Fig. 3.1 shows a liquid in a cylindrical container.

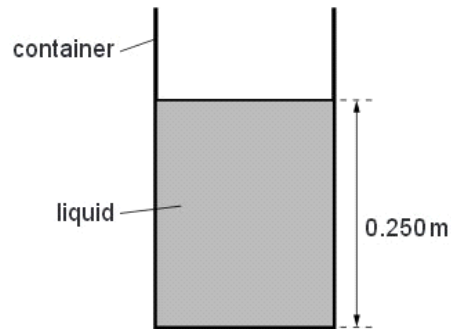


Fig. 3.1

The cross-sectional area of the container is 0.450 m^2 . The height of the column of liquid is 0.250 m and the density of the liquid is $13\,600 \text{ kg m}^{-3}$.

- (i) Calculate the weight of the column of liquid.

weight = ... N [3]

- (ii) Calculate the pressure on the base of the container caused by the weight of the liquid.

For
Examin
Use

pressure = ... Pa [1]

- (iii) Explain why the pressure exerted on the base of the container is different from the value calculated in (ii).

.....
..... [1]

Q17.

- 3 (a) With reference to the arrangement of atoms, distinguish between metals, polymers and amorphous solids.

Ext

metals:

.....

polymers:

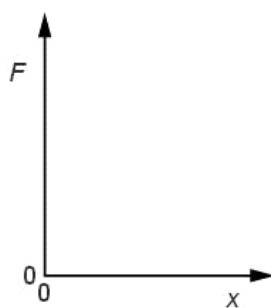
.....

amorphous solids:

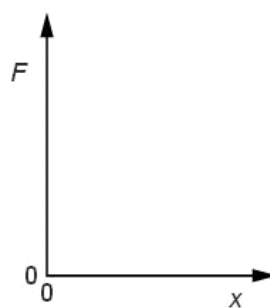
.....

[3]

- (b) On Fig. 3.1, sketch the variation with extension x of force F to distinguish between a metal and a polymer.



metal



polymer

Fig. 3.1

[2]

Q18.

- 1 A cylindrical disc is shown in Fig. 1.1.

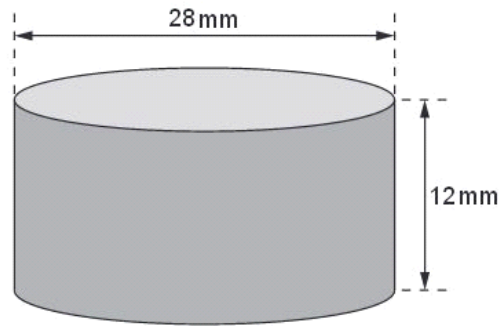


Fig. 1.1

The disc has diameter 28mm and thickness 12mm.
The material of the disc has density $6.8 \times 10^3 \text{ kg m}^{-3}$.

Calculate, to two significant figures, the weight of the disc.

weight = ... N [4]

Q1.

- | | | | | |
|---|-----|--|----------|-----|
| 2 | (a) | speck of light
that moves haphazardly/randomly/jerkily/etc. | B1
B1 | [2] |
| | (b) | randomness of collisions would be 'averaged out'
so less (haphazard) movement
(do not allow 'more massive so less movement') | B1
B1 | [2] |

Q2.

- | | | | | |
|---|---------|--|----------------|-----|
| 3 | (a) | sum of (random) kinetic and potential energies
of the atoms/molecules of the substance | M1
A1 | [2] |
| | (b) (i) | potential energy unchanged as atoms remain in same positions
<i>allow 'reduced because atoms slightly closer together'</i>
vibrational kinetic energy reduced because temperature lower
so internal energy less | M1
M1
A1 | [3] |
| | (ii) | potential energy increases because separation increases
kinetic energy unchanged because temperature unchanged
so internal energy increases | M1
M1
A1 | [3] |

Q3.

- | | | | | |
|---|---------|--|----------------|-----|
| 4 | (a) | mass per unit volume (<i>ratio idea must be clear, not units</i>) | B1 | [1] |
| | (b) (i) | pressure is same at the surface of <u>mercury</u>
because at same horizontal level | B1 | [1] |
| | (ii) | $h\rho g$ is same for both
$53 \times 10^{-2} \times 1.0 \times 10^3 \times g = 71 \times 10^{-2} \times \rho \times g$
$\rho = 7.5 \times 10^2 \text{ kg m}^{-3}$ | B1
C1
A1 | [3] |

Q4.

- | | | | | |
|---|---------|--|----------------|-----|
| 3 | (a) | mass / volume (<i>ratio idea essential</i>) | B1 | [1] |
| | (b) (i) | mass = $Ah\rho$ | B1 | [1] |
| | (ii) | pressure = force/area
weight (of liquid)/force (on base) = $Ah\rho g$
pressure = $h\rho g$ | B1
B1
A0 | [2] |
| | (c) (i) | ratio = 1600 or 1600:1 | A1 | [1] |
| | (ii) | ratio = $\sqrt[3]{1600}$
= 11.7 (<i>allow 12</i>) | C1
A1 | [2] |

- | | | | |
|---------|---|----------|-----|
| (d) (i) | density of solids and liquids are (about) equal | B1 | [1] |
| (ii) | strong forces: fixed volume
rigid forces: retains shape / does not flow / little deformation
(allow 1 mark for fixed volume, fixed shape) | B1
B1 | [2] |

Q5.

- | | | | |
|-----------|--|----------------------|-----|
| 4 (a) (i) | solid has fixed volume and fixed shape/incompressible | B1 | [1] |
| (ii) | gas fills any space into which it is put | B1 | [1] |
| (b) | atoms/molecules have (elastic) collisions with the walls (of the vessel)
momentum of atom/molecule changes
<u>so</u> impulse (on wall)/force on wall
random motion/many collisions (per unit time) gives rise to
(constant) force/pressure | B1
B1
B1
B1 | [4] |
| (c) | spacing (much) greater in gases than in liquids/about ten times
<i>either</i> spacing depends on $1/\sqrt[3]{\rho}$
<i>or</i> ratio of spacings is about 8.8 | C1
A1 | [2] |

Q6.

- | | | | |
|-------|---|---------|-----|
| 6 (a) | any two of:
large number of molecules / atoms / particles
molecules in random motion
no intermolecular forces
elastic collisions
time of collisions much less than time between collisions
volume of molecules much less than volume of containing vessel | B1 + B1 | [2] |
| (b) | molecules collide with the walls
<u>change in momentum</u> of molecules implies force (on molecules)
molecules exert equal and opposite force on wall
pressure is averaging effect of many collisions
(any three statements, 1 each) | B3 | [3] |

Q7.

- 7 (a) density in solids and liquids similar M1
 spacing in solids and liquids about the same A1
 density in gases much less as spacing in gases much greater B1 [3]
- (b) density = mass / volume C1
 mass = 1.67×10^{-27} kg and volume = $\frac{4}{3} \pi r^3$ C1
 density = $(1.67 \times 10^{-27}) / \frac{4}{3} \times \pi \times (1.0 \times 10^{-15})^3$
 = 3.99×10^{17} kg m⁻³ A1 [3]
- (c) atoms / molecules composed of large amount of empty space / nucleus has very small volume compared to volume of atom / space between atoms in a gas is very large B1 [1]

Q8.

- 3 (a) $V = h \times A$
 $m = V \times \rho$ B1
 $W = h \times A \times \rho \times g$ B1
 $P = F / A$ B1
 $P = h\rho g$
 P is proportional to h if ρ is constant (and g) B1 [4]
- (b) density changes with height B1
 hence density is not constant with link to formula B1 [2]

Q9.

- 4 (a) pressure = force / area (normal to force) A1 [1]
- (b) molecules/atoms/particles in (constant) random/haphazard motion B1
 molecules have a change in momentum when they collide with the walls M1
 (force exerted on molecules) therefore force on the walls A1
 reference to average force from many molecules/many collisions A1 [4]
- (c) elastic collision when kinetic energy conserved B1
 temperature constant for gas B1 [2]

Q10.

- 4 (a) apparatus: cell with particles e.g. smoke (container must be closed) B1
 diagram showing suitable arrangement with light illumination and microscope B1 [2]
- (b) specks / flashes of light M1
 in random motion A1 [2]
- (c) cannot see what is causing smoke to move hence molecules smaller than smoke particles (B1)
- continuous motion of smoke particles implies continuous motion of molecules (B1)
- random motion of particles implies random motion of molecules (B1)
- max. 2 [2]

Q11.

- 5 (a) metal: crystalline / lattice / atoms in regular pattern B1
 (atoms in regular) pattern that repeats itself (within crystal) B1 [2]
 polymer: long chains of atoms / molecules B1
 chain consists of 'units' that repeat themselves B1 [2]
- (b) (i) e.g. latex is soft / not strong / flows / ductile B1
 elastic limit easily exceeded B1 [2]
(allow any two sensible comments, 1 each)
- (ii) more solid / does not flow / stronger / higher ultimate tensile stress
 more brittle
 elastic limit much higher
 increased toughness
(any two, 1 each) B2 [2]

Q12.

- 5 (a) haphazard / random / erratic / zig-zag movement M1
 of (smoke) particles *(do not allow molecules / atoms)* A1 [2]
- (b) motion is due to unequal / unbalanced collision rates (on different faces) B1
 (unequal collision rate due to) random motion of (gas) molecules / atoms B1 [2]
- (c) *either* collisions with air molecules average out M1
 this prevents haphazard motion A1 [2]
or particle is more massive / heavier / has large inertia (M1)
 collisions cause only small movements / accelerations (A1)

Q13.

- 2 (a) (i) e.g. (phase) change from liquid to gas / vapour
thermal energy required to maintain constant temperature B1 [1]
(do not allow 'convert water to steam')
- (ii) e.g. evaporation takes place at surface B1
boiling takes place in body of the liquid B1
e.g. evaporation occurs at all temperatures B1
boiling occurs at one temperature B1 [4]
- (b) (i) volume = ($\frac{48}{4.5}$) 10.7 cm^3 A1 [1]
- (ii) 1 volume = $10.7 / (6.0 \times 10^{23})$
= $1.8 \times 10^{-23} \text{ cm}^3$ A1 [1]
2 separation = $\sqrt[3]{(1.8 \times 10^{-23})}$
= $2.6 \times 10^{-8} \text{ cm}$ A1 [1]

[Total: 8]

Q14.

- 2 crystalline: atoms / ions / particles in a regular arrangement / lattice
long range order / orderly pattern B1
(lattice) repeats itself (1)
- polymer: long chain molecules / chains of monomers B1
some cross-linking between chains / tangled chains (1)
- amorphous: disordered arrangement of molecules / atoms / particles B1
any ordering is short-range (1)
(three 'B' marks plus any other 2 marks) B2 [5]

Q15.

- 1 (a) density = mass / volume B1 [1]
- (b) density of liquids and solids same order as spacing similar / to about $2 \times$
density of gases much less as spacing much more B1
or density of gases much lower hence spacing much more B1 [2]
- (c) (i) density = $68 / [50 \times 600 \times 900 \times 10^{-9}]$ C1
= 2520 (allow 2500) kg m^{-3} A1 [2]
- (ii) $P = F / A$ C1
= $68 \times 9.81 / [50 \times 600 \times 10^{-6}]$ C1
= $2.2 \times 10^4 \text{ Pa}$ A1 [3]

Q16.

- 3 (a) pressure = force / area B1 [1]
- (b) molecules collide with object / surface and rebound B1
 molecules have change in momentum hence force acts B1
 fewer molecules per unit volume on top of mountain / temperature is less B1
 hence lower speed of molecules A0 [3]
 hence less pressure
- (c) (i) $\rho = m / V$ C1
 $W = V\rho g = 0.25 \times 0.45 \times 9.81 \times 13600$ C1
 $= 15000$ (15009) N A1 [3]
- (ii) $p = W / A$ (or using $p = \rho gh$) = 15009 / 0.45 A1 [1]
 $= 3.3 \times 10^4$ Pa
- (iii) pressure will be greater due to the air pressure (acting on the surface of the liquid) B1 [1]

Q17.

- 3 (a) metal: regular / repeated / ordered arrangement / pattern / lattice B1
 or long range order (of atoms / molecules / ions)
- polymer: tangled chains (of atoms / molecules) or long chains (of B1
 atoms / molecules / ions)
- amorphous: disordered / irregular arrangement or short range order B1 [3]
 (of atoms / molecules / ions)
- (b) metal: straight line or straight line then curving with less positive gradient B1
 polymer: curve with decreasing gradient with steep increasing gradient at end B1 [2]

Q18.

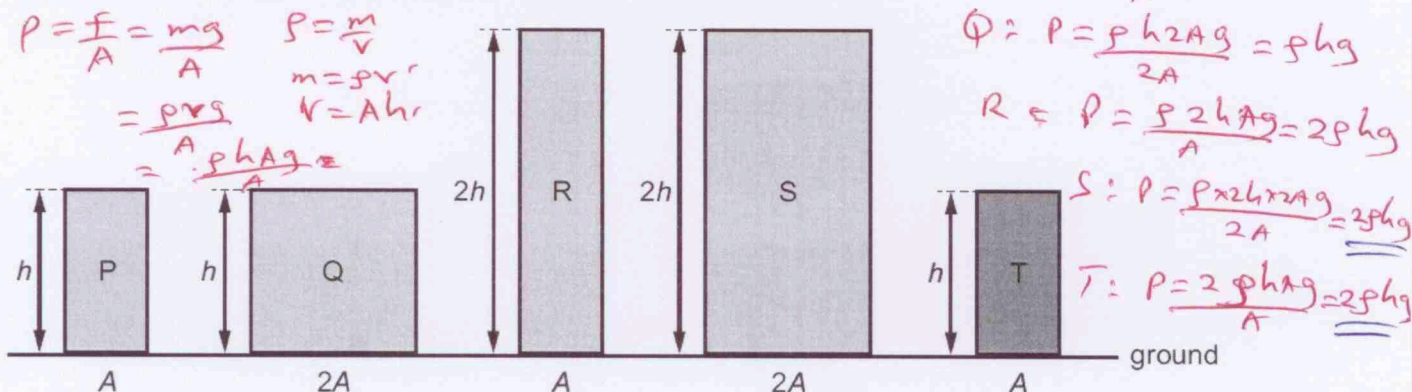
- 1 volume = $\pi (14 \times 10^{-3})^2 \times 12 \times 10^{-3}$ (=7.389 $\times 10^{-6}$ m³) C1
 density = mass / volume [any subject] C1
 mass = $6.8 \times 10^3 \times 7.389 \times 10^{-6}$ = 0.0502 C1
 weight = mg A1 [4]
 $= 0.0502 \times 9.81 = 0.49$ N (mark not awarded if not to **two** s.f.)

Density and Pressure - 2018

1. 9702/11/M/J/18/No.11

Blocks P, Q, R and S are made from material of the same density. Block T is made from a material of twice the density of the material of the other blocks.

The cross-sectional area and height of each of the blocks are shown.



Which two blocks exert the same pressure on the ground?

A P and T

B Q and R

C Q and S

D S and T

2. 9702/11/M/J/18/No.13

Liquids X and Y are stored in large open tanks. Liquid X has a density of 800 kg m^{-3} and liquid Y has a density of 1200 kg m^{-3} .

At which depths are the pressures equal?

	depth in liquid X / m	depth in liquid Y / m
A	8	20
B	10	15
C	15	10
D	20	8

$$\rho_x = 800, \rho_y = 1200$$

$$P = \rho g h$$

$$P_x = P_y ?$$

$$800 \times g \times h_x = 1200 \times g \times h_y$$

$$800 \times h_x = 1200 \times h_y$$

$$800 \times 15 = 1200 \times 10$$

$$\underline{12000 \text{ Pa}} = \underline{12000 \text{ Pa}}$$

3. 9702/12/M/J/18/No.10

The density of water is 1.0 g cm^{-3} and the density of glycerine is 1.3 g cm^{-3} .

Water is added to a measuring cylinder containing 40 cm^3 of glycerine so that the density of the mixture is 1.1 g cm^{-3} . Assume that the mixing process does not change the total volume of the liquid.

What is the volume of water added?

- A 40 cm^3 B 44 cm^3 C 52 cm^3 ☒ D 80 cm^3

$$\rho = \frac{m}{V}$$

$$m_g = 1.3 \times 40 = 52 \text{ g}$$

$$m_w = 1.0 \times V_w$$

$$1.1 = \frac{m_w + m_g}{V_w + V_g}$$

$$1.1 = \frac{1.0 \times V_w + 52}{V_w + 40}$$

$$1.1(V_w + 40) = V_w + 52$$

$$1.1V_w + 44 = V_w + 52$$

$$1.1V_w + 40 = V_w + 52$$

$$1.1V_w - V_w = 52 - 44$$

$$0.1V = 8$$

$$V = 80 \text{ cm}^3$$

4. 9702/12/M/J/18/No.12

A cylindrical block of wood has cross-sectional area A and weight W . It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively.

Which expression is equal to the upthrust on the block?

A $(p_b - p_t)$

☒ B $(p_b - p_t)A$

C $(p_b - p_t)A - W$

D $(p_b - p_t)A + W$

$$\text{Upthrust} = F_b - F_t$$

$$= p_b A - p_t A$$

$$= (p_b - p_t) A$$

$$F = p \times A$$

5. 9702/13/M/J/18/No.11

A rectangular block of lead of density $1.13 \times 10^4 \text{ kg m}^{-3}$ has sides of length 12.0 cm , 15.0 cm and 10.0 cm .

What is the maximum pressure the block can exert when resting on a table?

- A 1.13 kPa B 1.70 kPa C 11.1 kPa ☒ D 16.6 kPa

max. pressure when standing
on smaller area.

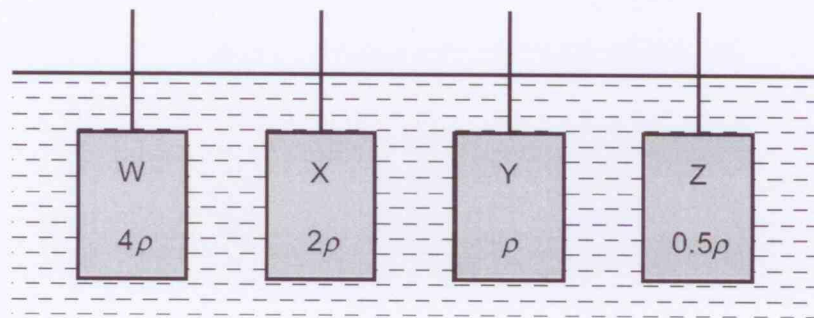
$$P = \frac{F}{A} = \frac{mg}{A} = \frac{1.13 \times 10^4 \times (0.12 \times 0.15 \times 0.10) \times 9.81}{0.12 \times 0.10}$$

$$= 16,627.95 \text{ Pa}$$

$$= 16.6 \text{ kPa}$$

6. 9702/13/M/J/18/No.10

Four cuboids with identical lengths, breadths and heights are immersed in water. The cuboids are held at the same depth and in identical orientations by vertical rods, as shown.



Water has density ρ .

Cuboid W is made of material of density 4ρ .

Cuboid X is made of material of density 2ρ .

Cuboid Y is made of material of density ρ .

Cuboid Z is made of material of density 0.5ρ .

Which statement is correct?

- ☒ A The upthrust of the water on each of the cuboids is the same.
- ☐ B The upthrust of the water on W is twice the upthrust of the water on X.
- ☐ C The upthrust of the water on X is twice the upthrust of the water on W.
- ☐ D The upthrust of the water on Y is zero.

7. 9702/13/M/J/18/No.13

Full-fat milk is made up of fat-free milk mixed with fat.

A volume of $1.000 \times 10^{-3} \text{ m}^3$ of full-fat milk has a mass of 1.035 kg. It contains 4.00% fat by volume.

The density of fat-free milk is $1.040 \times 10^3 \text{ kg m}^{-3}$.

What is the density of fat?

- ☐ A $1.25 \times 10^2 \text{ kg m}^{-3}$
- ☒ B $9.15 \times 10^2 \text{ kg m}^{-3}$
- ☐ C $9.28 \times 10^2 \text{ kg m}^{-3}$
- ☐ D $1.16 \times 10^3 \text{ kg m}^{-3}$

$$V_{\text{fat}} = \frac{1.0 \times 10^{-3} \times 4}{100} = 0.00004 \text{ m}^3$$

$$\rho_{\text{full fat}} = \frac{m_{\text{free}} + m_{\text{fat}}}{V_{\text{free}} + V_{\text{fat}}}$$

$$\rho_{\text{full fat}} = \frac{1.035}{1.0 \times 10^{-3}} = 1035 \text{ kg m}^{-3}$$

$$V_{\text{free}} = 1.0 \times 10^{-3} - 4.0 \times 10^{-5} = 9.6 \times 10^{-4} \text{ m}^3$$

$$m_{\text{free}} = \rho_{\text{free}} \times V_{\text{free}} = 1.040 \times 10^3 \times 9.6 \times 10^{-4} = 0.9984 \text{ kg}$$

$$1035 = \frac{0.9984 + m_{\text{fat}}}{9.6 \times 10^{-4} + 4 \times 10^{-5}}$$

$$1035 \times 0.001 = 0.9984 + m_{\text{free}}$$

$$m_{\text{fat}} = 1.035 - 0.9984 = 0.0366$$

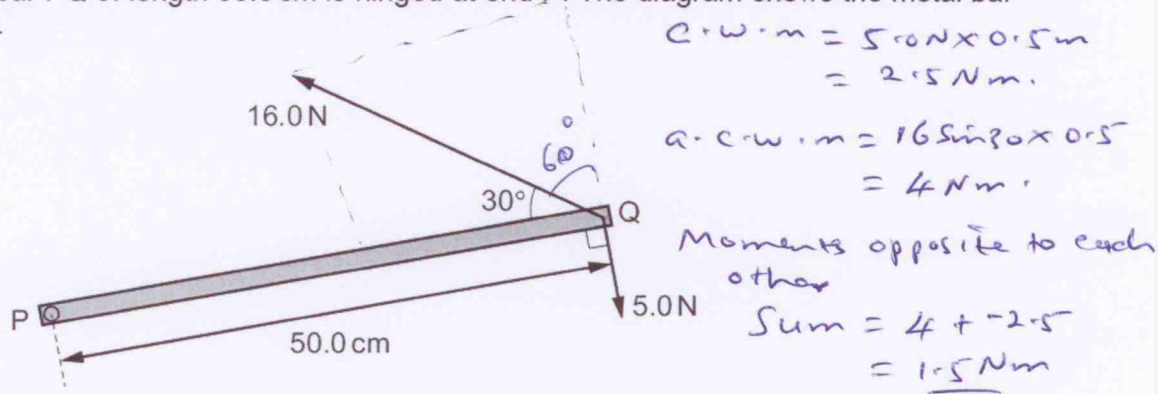
$$\rho_{\text{fat}} = \frac{m_{\text{fat}}}{V_{\text{fat}}}$$

$$= \frac{0.0366}{0.00004} = 915 \text{ kg m}^{-3} = 9.15 \times 10^2 \text{ kg m}^{-3}$$

Forces - 2018

1. 9702/11/M/J/18/No.10

A horizontal metal bar PQ of length 50.0 cm is hinged at end P. The diagram shows the metal bar viewed from above.



Two forces of 16.0 N and 5.0 N are in the horizontal plane and act on end Q as shown in the diagram.

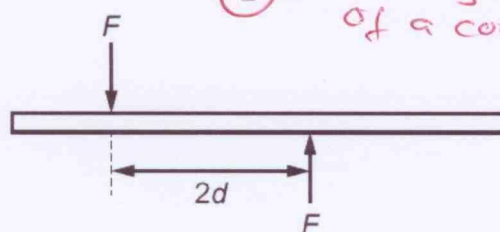
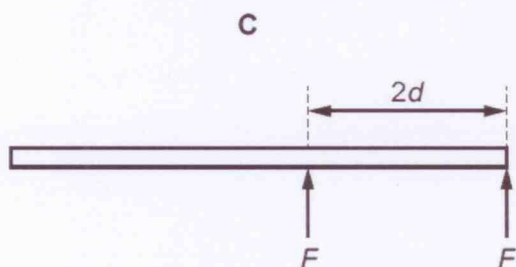
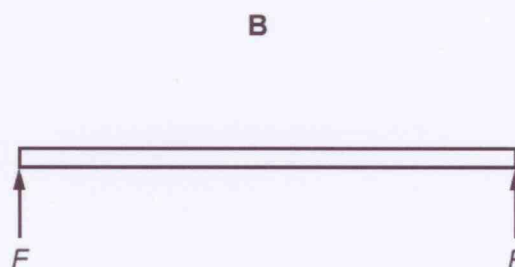
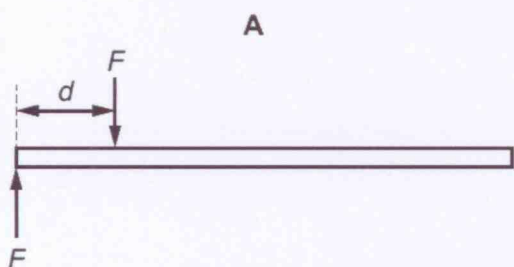
What is the total moment about P due to the two forces?

- ☒ A 1.5 Nm B 4.4 Nm C 6.5 Nm D 9.4 Nm

2. 9702/11/M/J/18/No.12

Two parallel forces, each of magnitude F , act on a rod of length $5d$.

Which diagram shows the positions of the two forces that will produce the largest torque on the rod?



✓ - Torque is the turning effect of a couple.
☒ D

3. 9702/12/M/J/18/No.11

An astronaut throws a stone horizontally near to the surface of the Moon, where there is no atmosphere.

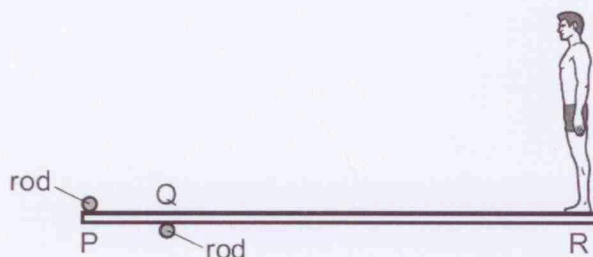
Which row describes the horizontal and vertical forces acting on the stone after release?

	horizontal force	vertical force
A	non-zero and constant	constant
B	non-zero and constant	decreasing
C	zero	constant
D	zero	decreasing

- horizontal speed is constant
 - so horizontal force is zero
 - vertical force is due to gravity of the moon which is constant

4. 9702/12/M/J/18/No.13

A uniform diving-board is held by two fixed rods at points P and Q. A person stands at end R of the diving-board, as shown.



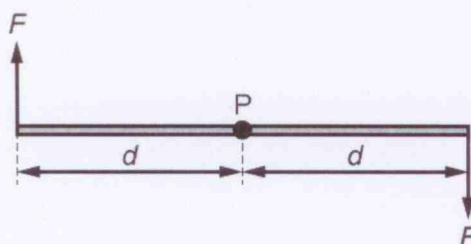
The forces exerted by the rods on the board are vertical. The board remains in equilibrium as the person slowly moves towards point Q from end R.

Which row describes the changes to the forces exerted by the rods on the board?

	force at P	force at Q
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

5. 9702/12/M/J/18/No.14

Two forces, each of magnitude F , act in opposite directions on a rod.



$\text{torque} = F \times d$
 $d = 2d$
 $= F \times 2d$
 $= \underline{\underline{2F \times d}}$

Each force acts on the rod at a distance d from the pivot P.

What is the torque of this couple about P?

A 0

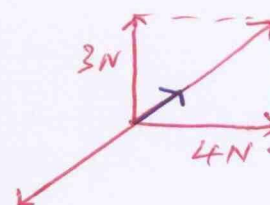
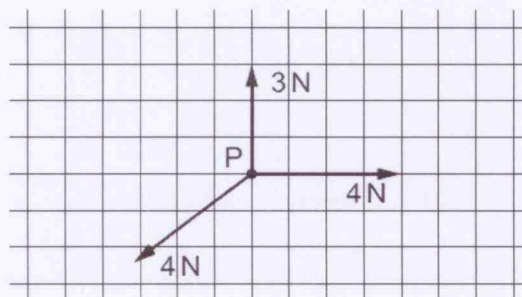
B $F \times d$

☒ C $2F \times d$

D $2F \times 2d$

6. 9702/12/M/J/18/No.15

The vector diagram shows three coplanar forces acting on an object at P.



The magnitude of the resultant of these three forces is 1 N.

What is the direction of this resultant force?

A ↙

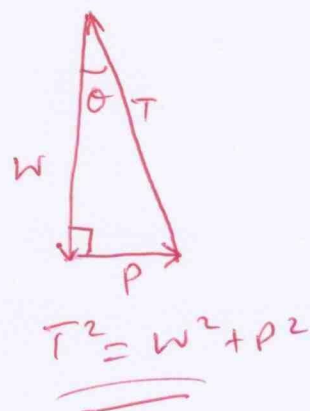
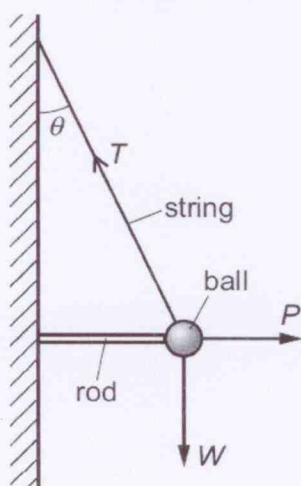
B ↘

C ↖

☒ D ↗

7. 9702/12/M/J/18/No.17

The diagram shows a ball of weight W hanging in equilibrium from a string.



The string is at an angle θ to the vertical. The tension in the string is T . The ball is held away from the wall by a horizontal force P from a metal rod.

What is the relationship between the magnitudes of T , P and W ?

A $P = T \cos \theta$ and $W = T \sin \theta$

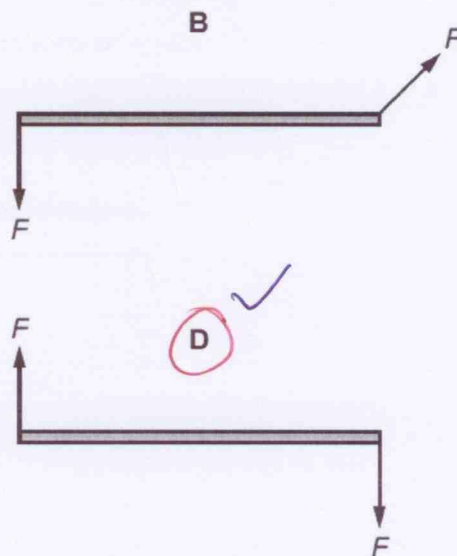
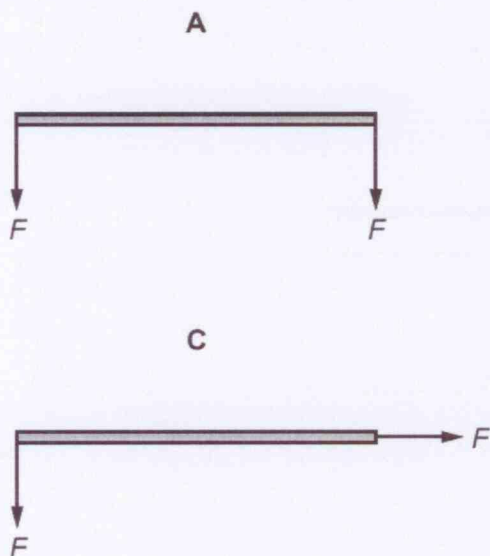
B $T = P + W$

☒ C $T^2 = P^2 + W^2$

D $W = P \tan \theta$ and $W = T \cos \theta$

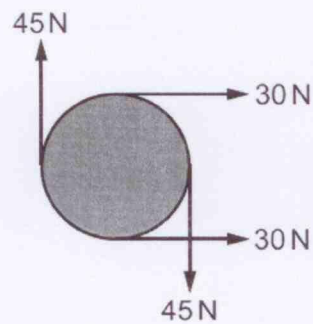
8. 9702/13/M/J/18/No.12

Which diagram shows a couple formed by two forces, each of magnitude F , acting on a rod?



9. 9702/12/F/M/18/No.11

The diagram shows four forces applied to a circular object.



- Forces 45 N creates a torque

- Forces 30 N has a resultant force.

Which row describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
☒ A	non-zero	non-zero
☐ B	non-zero	zero
☐ C	zero	non-zero
☐ D	zero	zero

10. 9702/12/F/M/18/No.13

In which example is it **not** possible for the underlined body to be in equilibrium?

- A An aeroplane climbs at a steady rate.
- B An aeroplane tows a glider at a constant altitude.
- ☒ C A speedboat changes direction at a constant speed.
- D Two boats tow a ship into harbour.

1. June/2021/Paper_11/No.14

Water of depth 9.0 cm is covered by oil of depth 5.0 cm in a measuring cylinder.

The density of the water is 1000 kg m^{-3} and the density of the oil is 800 kg m^{-3} .

What is the total pressure exerted on the base of the measuring cylinder due to the oil and water?

- A** 390 Pa **B** 880 Pa **C** 1200 Pa **D** 1300 Pa

2. June/2021/Paper_12/No.14

Each foot of an elephant has a circular cross-section with a circumference of 1.4 m. The elephant has a mass of 5400 kg.

The elephant is standing still with all four feet on the ground. Assume the pressure under each foot is the same.

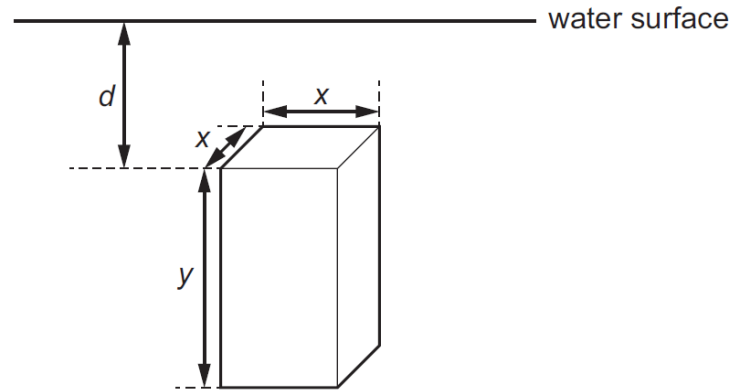
What is the approximate pressure exerted on the ground by each of the elephant's feet?

- A** 8.7 kPa **B** 35 kPa **C** 85 kPa **D** 340 kPa

3. Nov/2021/Paper_11/No.11

A uniform solid block is fully submerged in a tank of water.

The dimensions of the block are x and y , as shown.



The block is held vertically in the position shown. The density of the block is the same as the density of the water.

If the block is always held at the same depth d below the surface of the water, which single change would **increase** the magnitude of the upthrust force on the block?

- A decrease the density of the block
- B hold the block horizontally
- C increase dimension y
- D increase the density of the block

4. Nov/2021/Paper_11/No.14

A bird dives to a depth of 1.50 m below the surface of a lake. Atmospheric pressure is 101 kPa. The density of water is 1000 kg m^{-3} .

What is the pressure at this depth?

- A 14.7 kPa B 86.3 kPa C 103 kPa D 116 kPa

5. Nov/2021/Paper_12/No.11

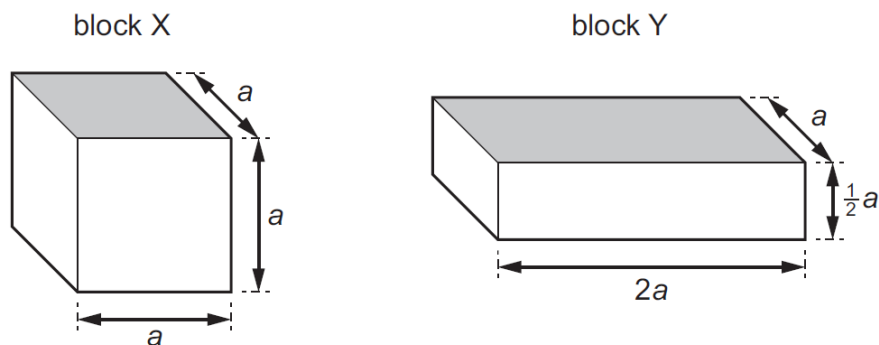
A cylindrical block of wood has cross-sectional area A and weight W . It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively.

What is the upthrust on the block?

- A $(p_b - p_t)$
- B $(p_b - p_t)A$
- C $(p_b - p_t)A - W$
- D $(p_b - p_t)A + W$

6. Nov/2021/Paper_13/No.15

The diagram shows two blocks X and Y.



Block X has sides of length a . When block X is placed in a liquid of density ρ with the shaded face level with the liquid surface, it experiences an upthrust U .

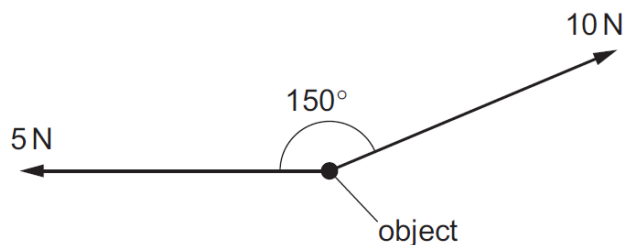
Block Y has horizontal sides of length a and $2a$ and height $\frac{1}{2}a$. Block Y is placed in a liquid of density 2ρ , also with the shaded face level with the liquid surface.

What is the upthrust on block Y?

- A $\frac{1}{2}U$
- B U
- C $2U$
- D $4U$

1. June/2021/Paper_11/No.3

A force of 10 N and a force of 5 N act on an object.



The angle between the forces is 150° .

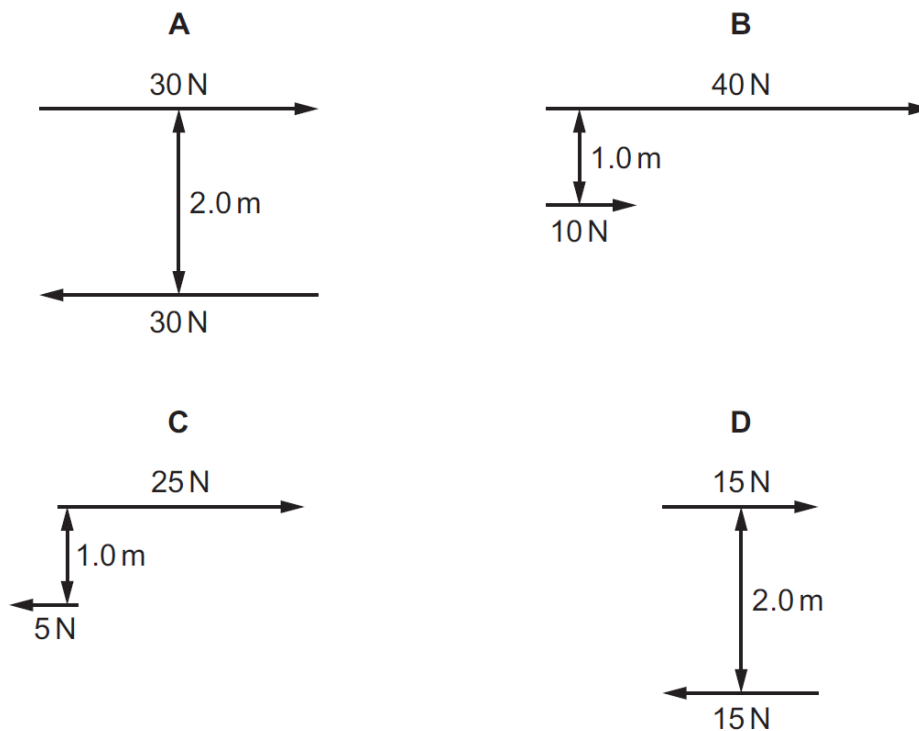
The resultant force on the object can be resolved into a pair of perpendicular components.

Which row shows numerical expressions for a possible pair of perpendicular components?

	force component / N	force component / N
A	$10 \cos 30^\circ - 5$	$10 \cos 30^\circ$
B	$10 \sin 30^\circ - 5$	$10 \cos 30^\circ$
C	$10 - 5 \cos 30^\circ$	$5 \sin 30^\circ$
D	$10 - 5 \sin 30^\circ$	$5 \cos 30^\circ$

2. June/2021/Paper_11/No.12

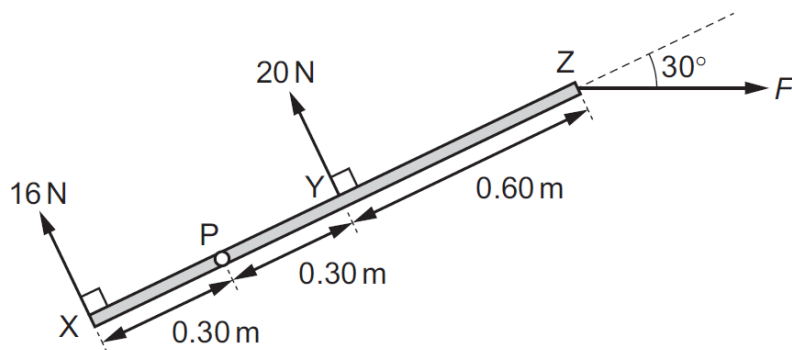
Which pair of forces forms a couple with a torque of 30 N m ?



3. [June/2021/Paper_11/No.13](#)

A uniform rigid bar XZ with negligible mass is 1.20 m long. The bar is pivoted at point P. Three coplanar forces act on the bar as shown. Forces of 16 N and 20 N act perpendicularly to the bar at points X and Y respectively. Force F acts at point Z at an angle of 30° to the axis of the bar.

The distances along the bar of the pivot and of the forces are shown.



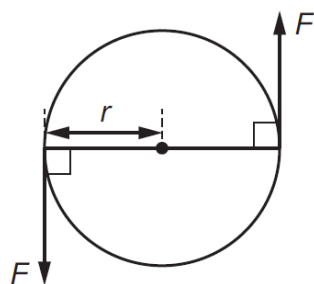
The bar experiences a resultant moment about P of 6.0 N m in a clockwise direction.

What is the magnitude of F ?

- A** 9.2 N **B** 11 N **C** 16 N **D** 24 N

4. [June/2021/Paper_12/No.12](#)

A disc of radius r is acted upon by two opposite forces, each of magnitude F . The forces form a couple, as shown.

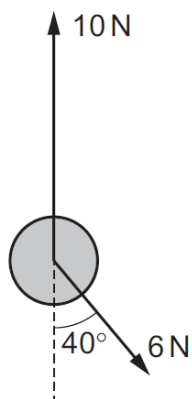


What is the torque of this couple?

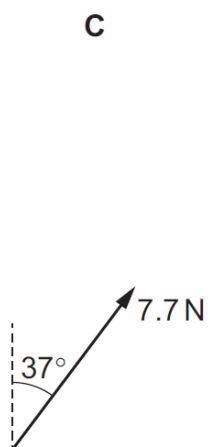
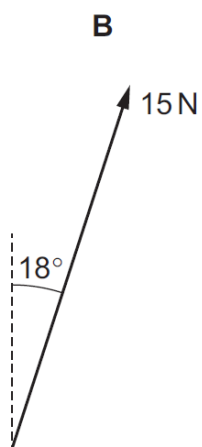
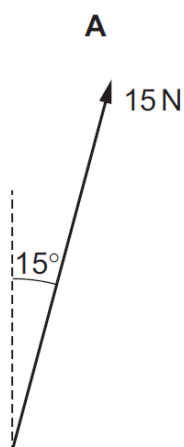
- A** $\frac{1}{2} Fr$ **B** Fr **C** $2Fr$ **D** $4Fr$

5. June/2021/Paper_12/No.3

An object is acted upon by two forces, 10 N in the vertical direction and 6 N at 40° to the vertical, as shown.

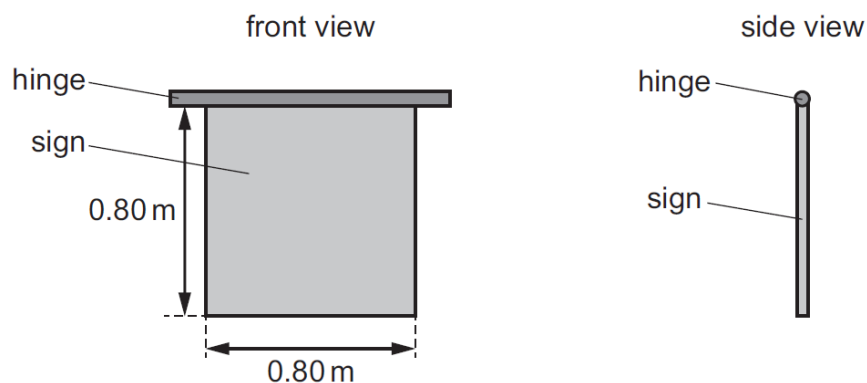


What is the resultant force acting on the object?



6. June/2021/Paper_12/No.13

A uniform square sign of weight 40 N is suspended vertically from its top edge by a horizontal hinge, as shown.



The hinge is not frictionless. When the sign is displaced from the vertical by an external force and then released, it does not return to the vertical position.

The maximum torque exerted by the hinge on the sign is 6.0 N m. The sign is displaced by 90° so that it is horizontal and then gradually released.

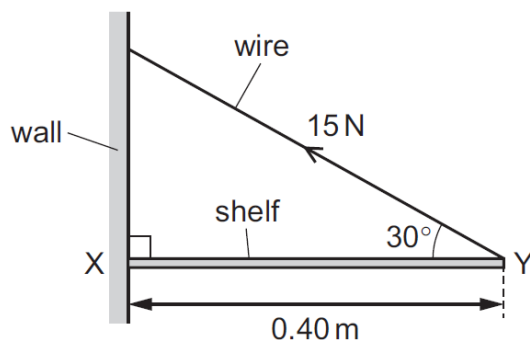
At which angle to the vertical does the sign hang after release?

- A** 11° **B** 22° **C** 68° **D** 79°

7. Nov/2021/Paper_11/No.12

A shelf XY is 0.40 m long and is attached to a wall at end X.

It is kept horizontal by a wire attached to Y and to the wall, as shown.



The tension force in the wire is 15 N at an angle of 30° to the horizontal.

What is the moment of this force about point X?

- A** 3.0 Nm **B** 5.2 Nm **C** 6.9 Nm **D** 12 Nm

8. Nov/2021/Paper_11/No.13

A statement about the principle of moments with some words omitted is shown.

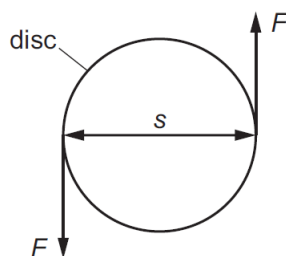
‘For an object in a state of rotational equilibrium, the sum of the clockwise moments about any point is equal to the sum of the anticlockwise moments about’

Which words correctly complete the statement?

- A** any point
B the centre of gravity of the object
C the pivot
D the same point

9. Nov/2021/Paper_12/No.12

Two forces, each of magnitude F , act on a disc of diameter s , as shown.

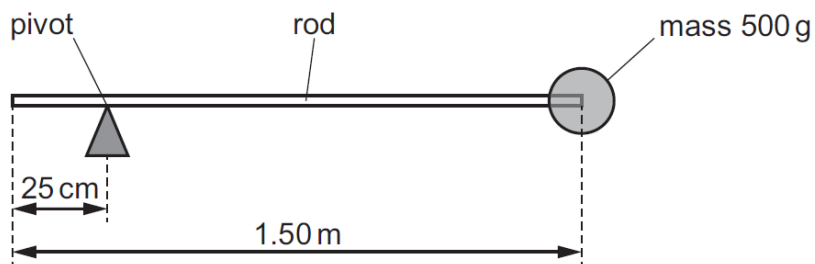


What is the torque exerted on the disc?

- A** zero **B** $\frac{1}{2}Fs$ **C** Fs **D** $2Fs$

10. Nov/2021/Paper_12/No.13

A mass of 500 g is attached at one end of a rod of length 1.50 m. The rod is pivoted at a distance of 25 cm from the other end. The rod is horizontal.

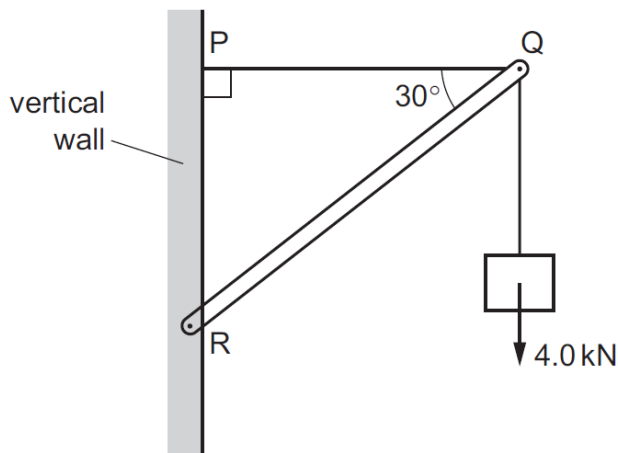


What is the moment about the pivot due to the mass?

- A 0.63 Nm B 1.2 Nm C 6.1 Nm D 7.4 Nm

11. Nov/2021/Paper_12/No.14

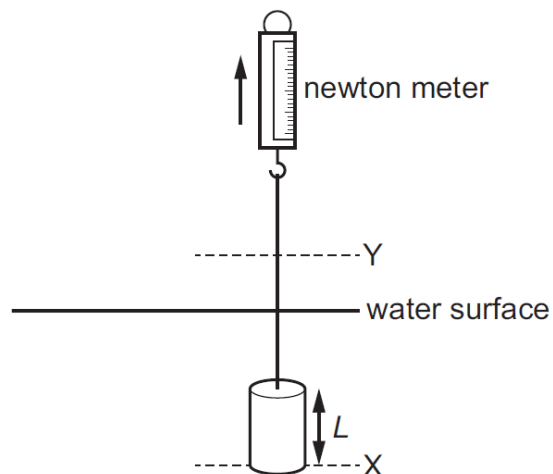
A beam QR is held in position by a wire PQ. The structure is used to form a crane supporting a stationary load of 4.0 kN, as shown.



What is the force exerted by the beam QR on point Q?

- A 4.0 kN B 4.6 kN C 6.9 kN D 8.0 kN

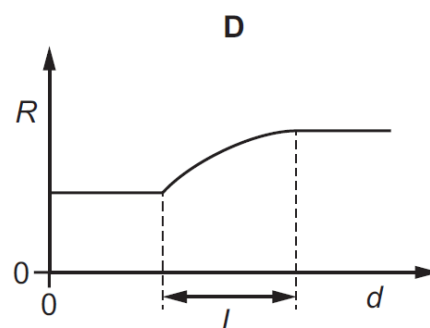
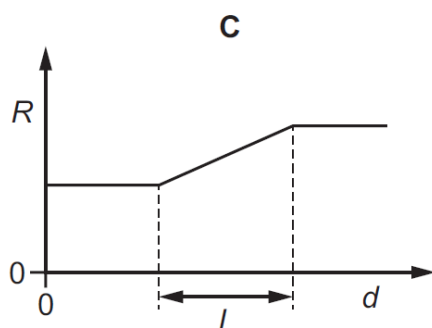
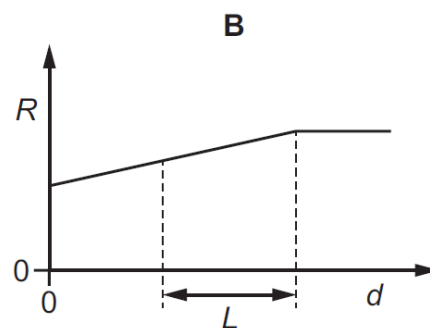
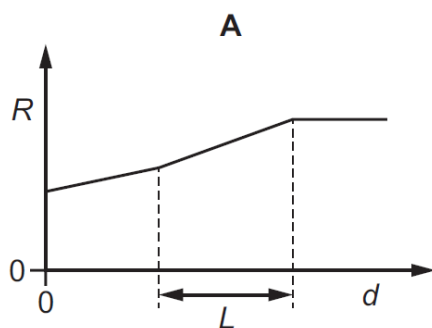
A metal cylinder, totally immersed in water, is hung from a newton meter.



The cylinder, of height L , is slowly raised vertically by lifting the newton meter.

As the base of the cylinder moves from line X in the water to line Y above the surface of the water, the reading R on the newton meter is recorded. The velocity of the cylinder is constant.

Which graph best shows the variation of R with the distance d of the base of the cylinder from line X?



13. Nov/2021/Paper_13/No.12

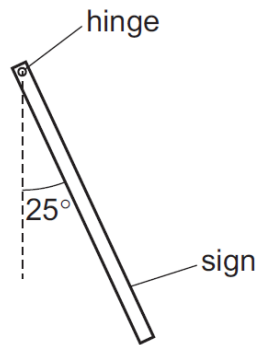
Two forces act as a couple.

Which statement about the two forces must **not** be correct?

- A They act along the same straight line.
- B They act in opposite directions.
- C They are the same type of force.
- D They have the same magnitude.

14. Nov/2021/Paper_13/No.13

A sign outside a shop is suspended from a rusty horizontal hinge at its top end. The sign hangs in equilibrium at an angle of 25° to the vertical, as shown.



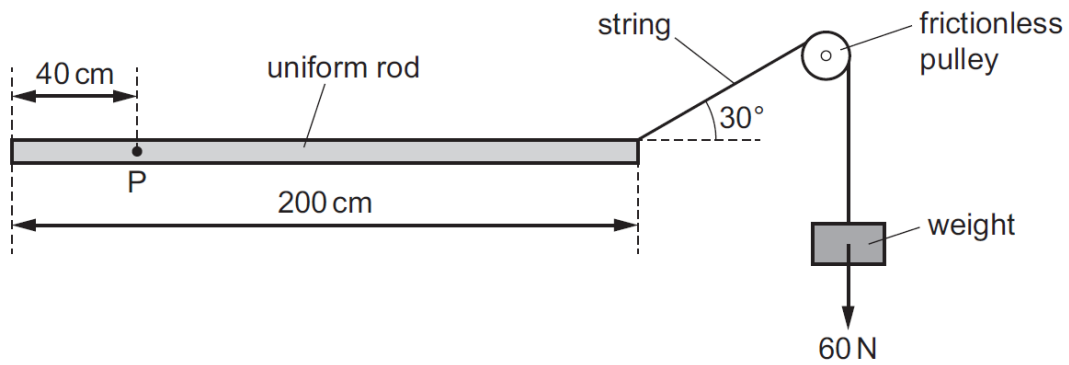
The sign is a square of side length 52 cm and uniform thickness. It has a mass of 36 kg.

What is the moment of the weight of the sign about the hinge?

- A 39 Nm B 78 Nm C 83 Nm D 92 Nm

15. Nov/2021/Paper_13/No.14

A uniform rod of length 200 cm is freely pivoted at point P. The rod is held horizontally in equilibrium by a 60 N weight that is attached to the rod by a string passing over a frictionless pulley.



What is the weight of the rod?

- A 30 N B 60 N C 80 N D 140 N

1. Nov/2021/Paper_23/No.1

- (a) A solid cylinder of weight 24 N is made of material of density 850 kg m^{-3} . The cylinder has a length of 0.18 m, as shown in Fig. 1.1.

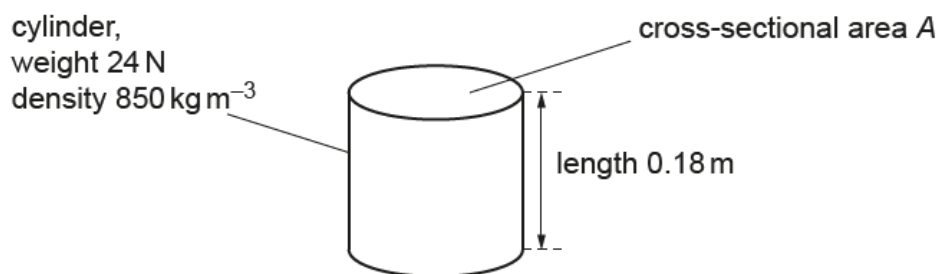


Fig. 1.1

Show that the cross-sectional area A of the cylinder is 0.016 m^2 .

[3]

- (b) The cylinder in (a) is attached by a spring to the bottom of a rigid container of liquid, as shown in Fig. 1.2.

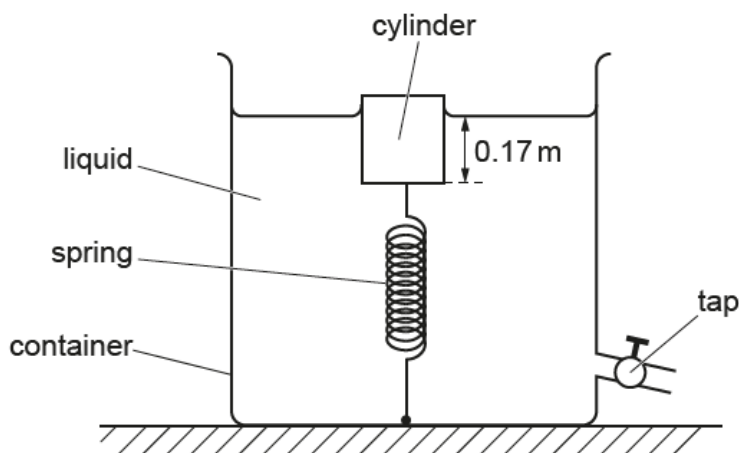


Fig. 1.2 (not to scale)

The cylinder is in equilibrium with its bottom face at a depth of 0.17 m below the surface of the liquid. The tension in the spring is 8.0 N.

- (i) Show that the upthrust acting on the cylinder due to the liquid is 32 N.

[1]

(ii) Calculate the density of the liquid.

density = ... kg m^{-3} [3]

(c) Fig. 1.3 shows the variation of the tension F with the length of the spring in (b).

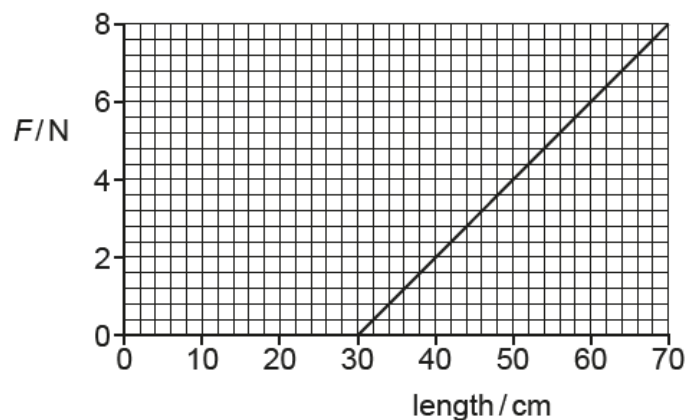


Fig. 1.3

- (i) The tap at the bottom of the container is opened so that a fixed amount of liquid flows out of the container. The cylinder moves downwards so that the tension in the spring changes from 8.0 N to 4.0 N.

Determine the change in the elastic potential energy of the spring.

change in elastic potential energy = ... J [3]

- (ii) More liquid is let out of the container until the upthrust on the cylinder becomes 24 N.

For the upthrust of 24 N, determine the length of the spring.

length = ... cm [1]

[Total: 11]

A pendulum consists of a solid sphere suspended by a string from a fixed point P, as shown in Fig. 3.1.

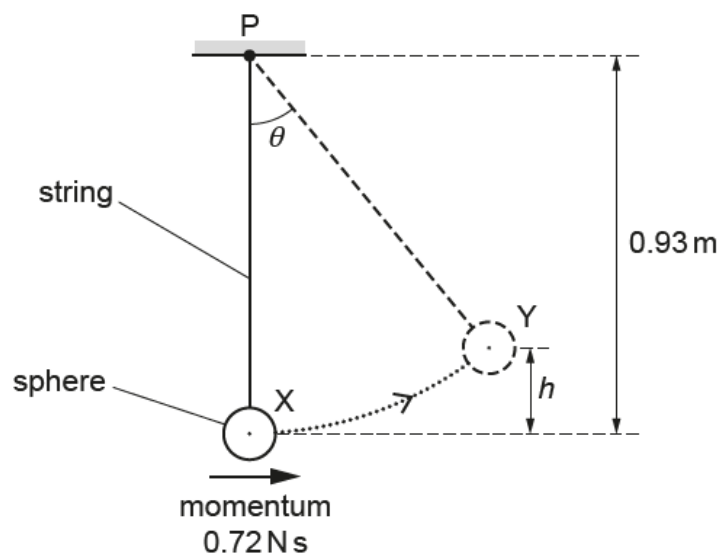


Fig. 3.1 (not to scale)

The sphere swings from side to side. At one instant the sphere is at its lowest position X, where it has kinetic energy 0.86 J and momentum 0.72 N s in a horizontal direction. A short time later the sphere is at position Y, where it is momentarily stationary at a maximum vertical height h above position X.

The string has a fixed length and negligible weight. Air resistance is also negligible.

(a) On Fig. 3.1, draw a solid line to represent the displacement of the centre of the sphere at position Y from position X. [1]

(b) Show that the mass of the sphere is 0.30 kg.

(c) Calculate height h .

$h = \dots\dots\dots$ m [2]

(d) The distance between point P and the centre of the sphere is 0.93m. When the sphere is at position Y, the string is at an angle θ to the vertical.

Show that θ is 47° .

[1]

(e) For the sphere at position Y, calculate the moment of its weight about point P.

moment = $\dots\dots\dots$ Nm [2]

(f) State and explain whether the sphere is in equilibrium when it is stationary at position Y.

$\dots\dots\dots$

$\dots\dots\dots$ [1]

[Total: 10]

(a) Complete Table 1.1 by stating whether each of the quantities is a vector or a scalar.

Table 1.1

quantity	vector or scalar
acceleration	
electrical resistance	
momentum	

[2]

(b) State the conditions for an object to be in equilibrium.

.....

.....

.....

..... [2]

(c) A floating solid cylinder is attached by a wire to the sea bed, as shown in Fig. 1.1.

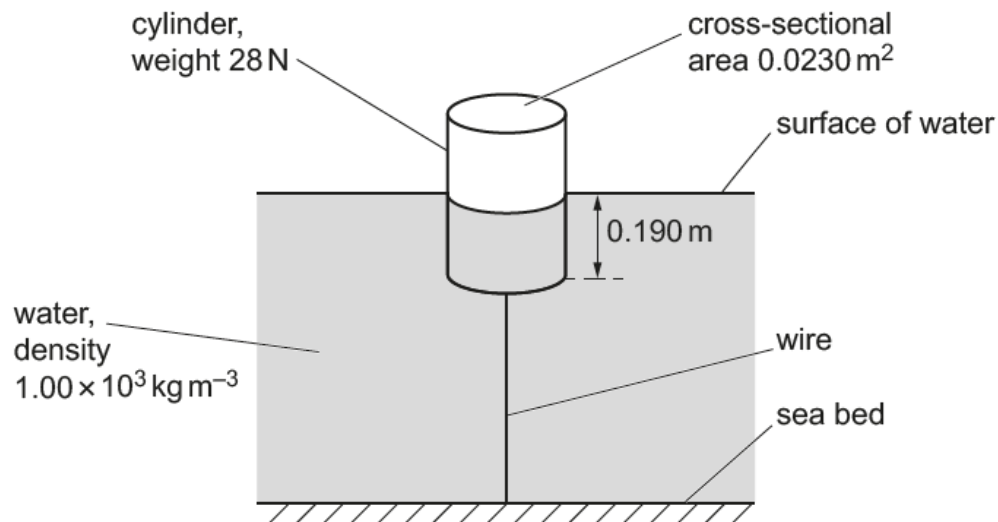


Fig. 1.1 (not to scale)

The density of the water is $1.00 \times 10^3 \text{ kg m}^{-3}$. The base of the cylinder is at a depth of 0.190 m below the surface of the water. The cylinder has a weight of 28 N and a cross-sectional area of 0.0230 m^2 .

The wire and the central axis of the cylinder are both vertical. The cylinder is in equilibrium.

- (i) Calculate, to three significant figures, the upthrust acting on the cylinder due to the water.

upthrust = ... N [2]

- (ii) Show that the tension T in the wire is 15 N.

[1]

- (iii) The wire has a cross-sectional area of 3.2 mm^2 .

Calculate the stress in the wire.

stress = ... Pa [2]

- (iv) The surface of the water gradually rises until it is level with the top face of the cylinder.

State and explain, qualitatively, the variation of the strain energy stored in the wire as the water surface rises.

.....
.....
.....
..... [2]

[Total: 11]

(a) Define the *moment* of a force about a point.

.....

.....

..... [2]

(b) Fig. 3.1 shows a type of balance that is used for measuring mass.

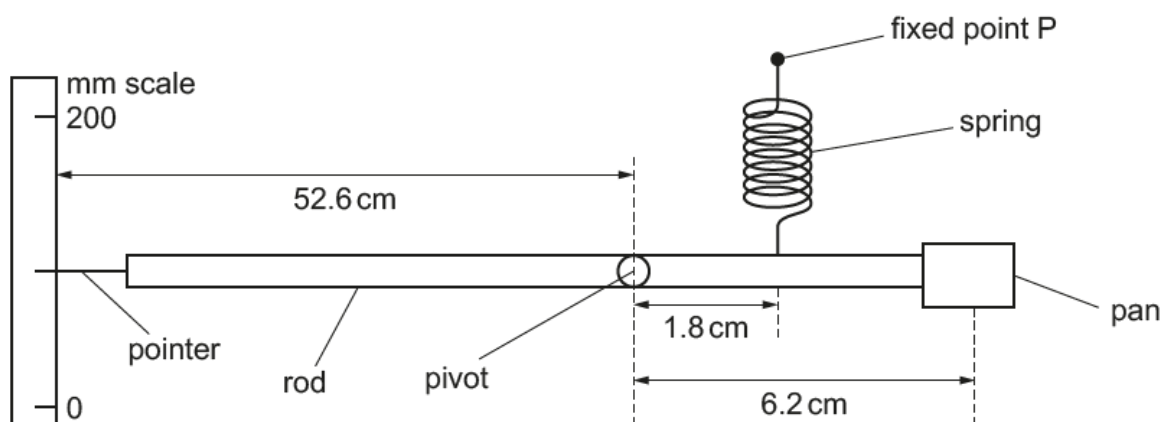


Fig. 3.1 (not to scale)

A rigid rod is pivoted about a point 6.2 cm from the centre of a pan which is attached to one end. The object being measured is placed on the centre of this pan.

A spring, attached to the rod 1.8 cm from the pivot, is attached at its other end to a fixed point P. The spring obeys Hooke's law over the full range of operation of the balance.

A pointer, on the other side of the pivot, is set against a millimetre scale which is a distance 52.6 cm from the pivot.

When the system is in equilibrium with no mass on the pan, the rod is horizontal and the pointer indicates a reading on the scale of 86 mm.

An object of mass 0.472 kg is now placed on the pan. As a result, the pointer moves to indicate a reading of 123 mm on the scale when the system is again in equilibrium.

(i) Show that the increase in the length of the spring is approximately 1.3 mm.

[2]

- (ii) Calculate the magnitude of the moment about the pivot of the weight of the object.

moment = ... Nm [2]

- (iii) Use your answer in (b)(ii) to determine the increase in the tension in the spring due to the 0.472 kg mass.

increase in tension = ... N [2]

- (iv) Use the information in (b)(i) and your answer in (b)(iii) to determine the spring constant k of the spring. Give a unit with your answer.

k = ... unit [2]

[Total: 10]

(c) (i) Define *force*.

.....
 [1]

(ii) The motion represented in Fig. 1.1 is caused by a resultant force F acting on the object.

On Fig. 1.2, sketch the variation of F with time t from $t = 0$ to $t = 12.0$ s.
 Numerical values of F are not required.

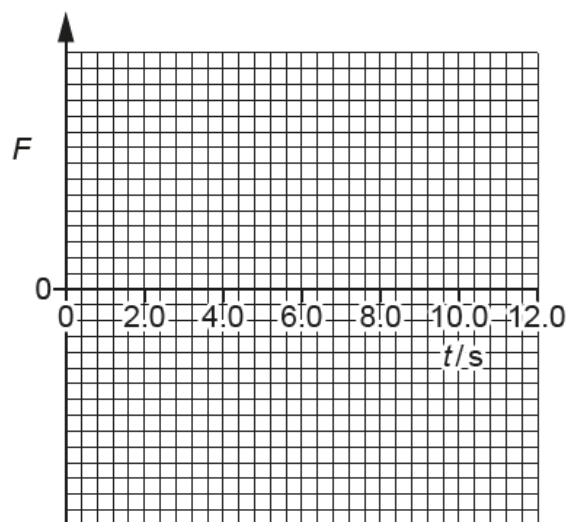


Fig. 1.2

[3]

[Total: 10]

1. June/2023/Paper_9702/11/No.14

Which expression for pressure is correct?

- A** force per unit area
- B** force per unit volume
- C** mass per unit area
- D** mass per unit volume

2. June/2023/Paper_9702/11/No.15

A ball has a mass of 0.50 kg and a volume of $1.3 \times 10^{-3} \text{ m}^3$. The ball is floating in equilibrium on still water. The two forces that act on the ball are its weight and the upthrust due to the water.

The density of the water is $1.0 \times 10^3 \text{ kg m}^{-3}$.

What is the percentage of the volume of the ball above the surface of the water?

- A** 3.9% **B** 38% **C** 62% **D** 96%

3. June/2023/Paper_9702/12/No.13

Two solid cubes X and Y are made of material of the same density. Cube X has twice the mass of cube Y.

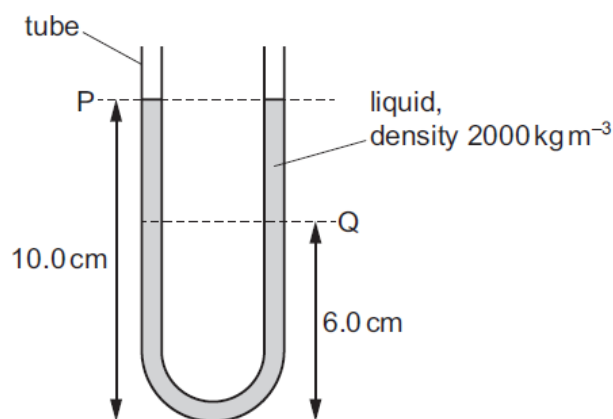
Cube X has sides of length x . Cube Y has sides of length y .

What is the ratio $\frac{x}{y}$?

- A** 1.26 **B** 1.41 **C** 2.00 **D** 8.00

4. June/2023/Paper_9702/12/No.14

A U-shaped glass tube contains liquid of density 2000 kg m^{-3} , as shown.



What is the difference in pressure due to the liquid between levels P and Q?

- A** 780 Pa **B** 1200 Pa **C** 1600 Pa **D** 2000 Pa

5. June/2023/Paper_9702/13/No.13

A volume of 1.5 m^3 of water is mixed with 0.50 m^3 of alcohol. The density of water is 1000 kg m^{-3} and the density of alcohol is 800 kg m^{-3} .

The volume of the mixture is 2.0 m^3 .

What is the density of the mixture?

- A 850 kg m^{-3} B 900 kg m^{-3} C 940 kg m^{-3} D 950 kg m^{-3}

6. June/2023/Paper_9702/13/No.14

An object is falling at a constant speed through a viscous liquid. F_U is the upthrust on the object due to the liquid. W_L is the weight of the liquid displaced by the object. W_O is the weight of the object.

Which equation **must** be correct?

- A $F_U = W_L$
B $F_U = W_O - W_L$
C $F_U = W_O$
D $F_U = W_O + W_L$

A beaker in air contains a liquid. The base of the beaker is in contact with the liquid and has area A , as shown in Fig. 4.1.

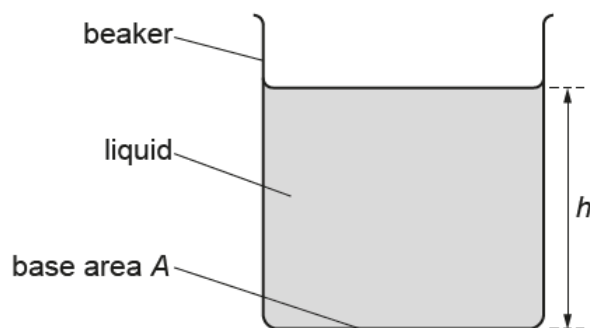


Fig. 4.1

The liquid has density ρ and fills the beaker to a depth h .

- (a) By using the definitions of pressure and density, show that

$$p = \rho gh$$

where p is the pressure due to the liquid that is exerted on the base of the beaker and g is the acceleration of free fall.

[3]

- (b) Suggest why the equation in (a) does not give the total pressure on the base of the beaker.

.....
 [1]

- (c) Fig. 4.2 shows the variation of the total pressure inside the liquid with depth x below the surface.

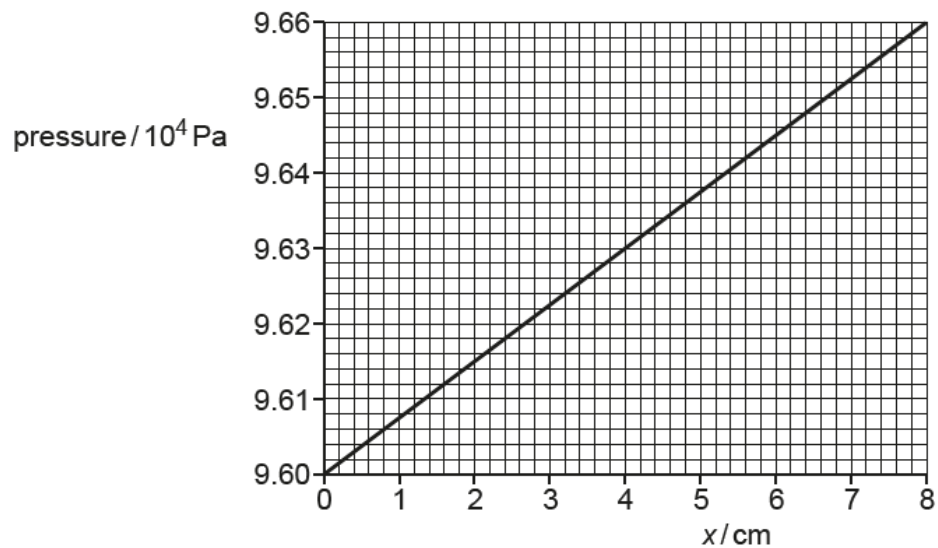


Fig. 4.2

Determine the density of the liquid.

density = ... kg m^{-3} [2]

- (d) A solid cylinder is held stationary by a wire so that the base of the cylinder is level with the surface of the liquid, as shown in Fig. 4.3.

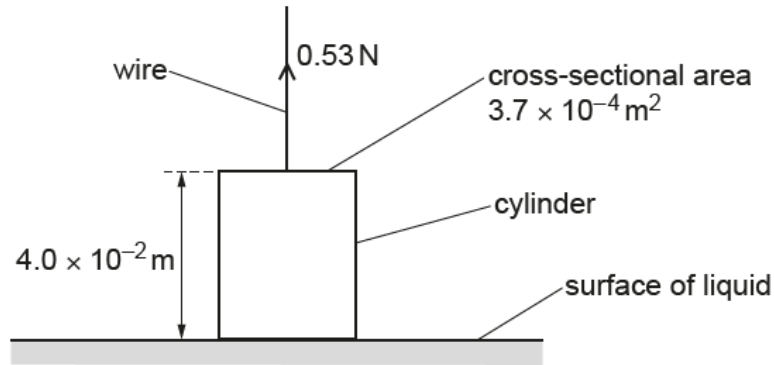


Fig. 4.3 (not to scale)

The cylinder has length $4.0 \times 10^{-2} \text{ m}$ and cross-sectional area $3.7 \times 10^{-4} \text{ m}^2$. The tension in the wire is 0.53 N.

The cylinder is now lowered and then held stationary by the wire so that the top of the cylinder is level with the surface of the liquid.

Calculate the new tension in the wire.

tension = ... N [2]

[Total: 8]

A sphere floats in equilibrium on the surface of sea water of density 1050 kg m^{-3} , as shown in Fig. 2.1.

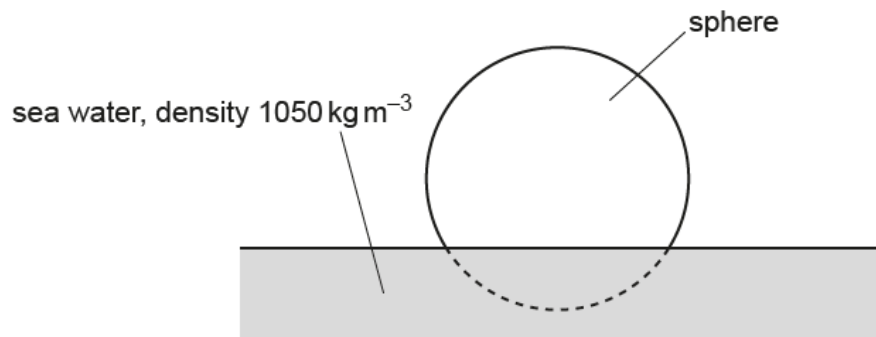


Fig. 2.1

- (a) 21% of the volume of the sphere is below the surface of the water.

Calculate the density of the sphere.

density = ... kg m^{-3} [2]

- (b) The sphere is now held so that its entire volume is below the surface of the water. The sphere is then released.

- (i) Calculate the initial acceleration of the sphere.

acceleration = ... ms^{-2} [3]

- (ii) The sphere accelerates upwards but remains entirely below the surface of the water.

State and explain what happens to the acceleration of the sphere as its velocity begins to increase.

.....

.....

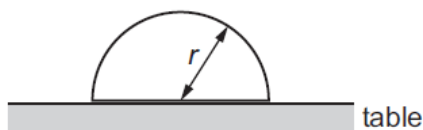
.....

..... [3]

[Total: 8]

9. March/2023/Paper_9702/12/No.13

An object shaped as a hemisphere rests with its flat surface on a table. The object has radius r and density ρ .



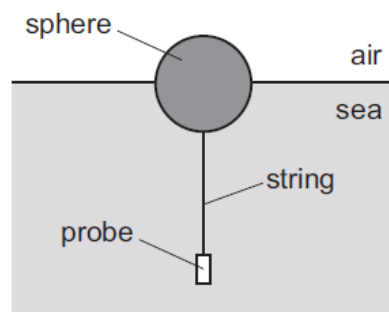
The volume of a sphere is $\frac{4}{3}\pi r^3$.

Which average pressure does the object exert on the table?

- A $\frac{1}{3}\rho r^2$ B $\frac{1}{3}\rho r^2 g$ C $\frac{2}{3}\rho r$ D $\frac{2}{3}\rho r g$

10. March/2023/Paper_9702/12/No.14

A probe is used to monitor the quality of the water in the sea. The probe is suspended by a vertical string which is attached to a sphere. The stationary sphere floats in equilibrium on the surface of the sea, as shown.



The sphere has a weight of 5.00 N. The probe and string have a combined weight of 2.00 N.

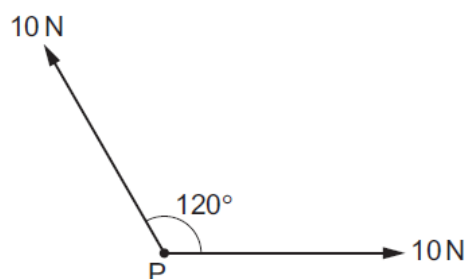
The density of the seawater is $1.03 \times 10^3 \text{ kg m}^{-3}$. The upthrust acting on the probe and thread is negligible.

What is the volume of the sphere below the surface of the sea?

- A $1.98 \times 10^{-4} \text{ m}^3$
 B $2.97 \times 10^{-4} \text{ m}^3$
 C $4.95 \times 10^{-4} \text{ m}^3$
 D $6.93 \times 10^{-4} \text{ m}^3$

1. June/2023/Paper_9702/11/No.24

Two forces, each of 10 N, act at a point P, as shown. The angle between the directions of the forces is 120° .

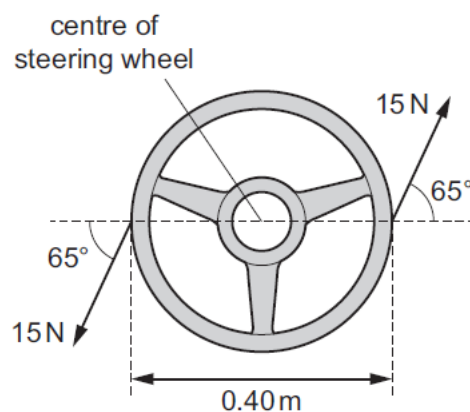


What is the magnitude of the resultant force?

- A** 5 N **B** 10 N **C** 17 N **D** 20 N

2. June/2023/Paper_9702/11/No.11

The driver of a car applies two parallel forces to a steering wheel, as shown.



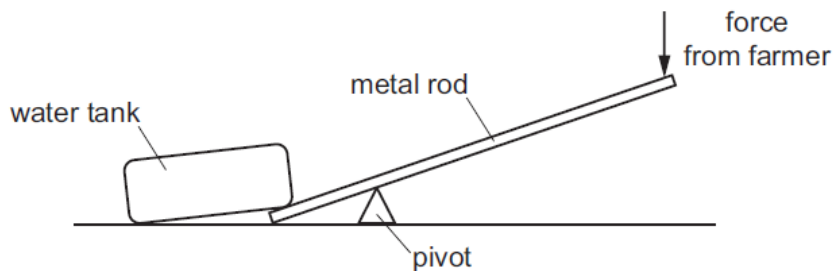
Each force has a magnitude of 15 N and acts in the direction shown. The steering wheel has a diameter of 0.40 m.

What is the torque exerted on the steering wheel?

- A** 1.3 Nm **B** 2.5 Nm **C** 2.7 Nm **D** 5.4 Nm

3. June/2023/Paper_9702/11/No.12

A farmer is trying to lift the corner of a large water tank. She uses a metal rod as a lever.



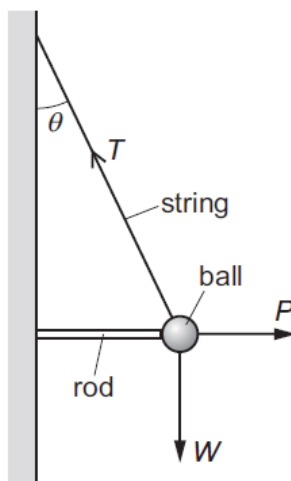
The vertical force from the farmer is constant and is always applied to the end of the rod.

Which change **must** increase the upward force on the water tank?

- A using a longer rod and moving the pivot closer to the tank
- B using a longer rod and moving the pivot further away from the tank
- C using a shorter rod and moving the pivot closer to the tank
- D using a shorter rod and moving the pivot further away from the tank

4. June/2023/Paper_9702/11/No.13

The diagram shows a ball of weight W hanging in equilibrium from a string.



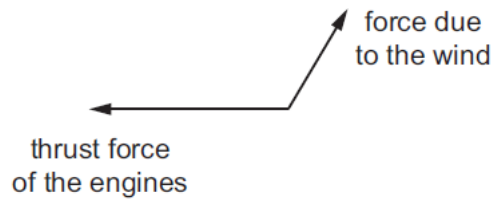
The string is at an angle θ to the vertical. The tension in the string is T . The ball is held away from the wall by a horizontal force P from a metal rod.

Which relationship between the magnitudes of T , P and W is correct?

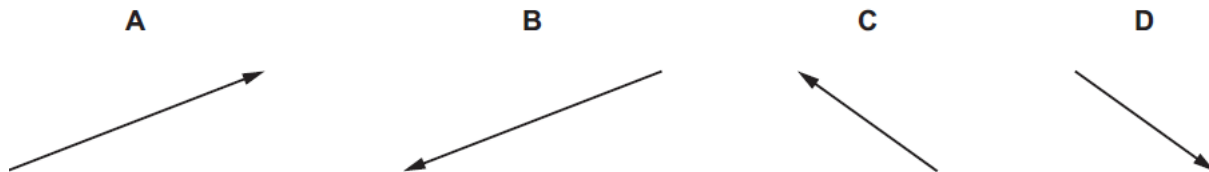
- A $P = T \cos \theta$ and $W = T \sin \theta$
- B $T = P + W$
- C $T^2 = P^2 + W^2$
- D $W = P \tan \theta$ and $W = T \cos \theta$

5. June/2023/Paper_9702/12/No.4

An aircraft travels along a horizontal path. Two of the forces that act horizontally on the aircraft are the thrust force of the engines and the force due to the wind. The vector diagram for these forces is shown.



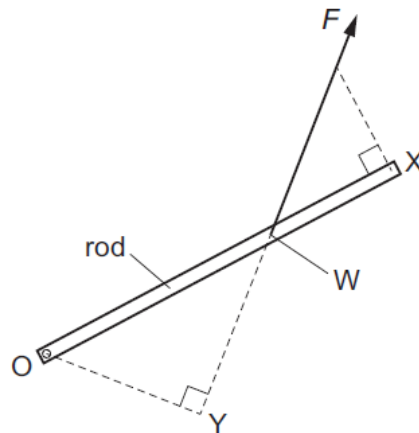
Which vector represents the resultant horizontal force acting on the aircraft due to these two forces?



6. June/2023/Paper_9702/12/No.11

A rod is pivoted at point O.

A force F is applied to the rod at point W, as shown.

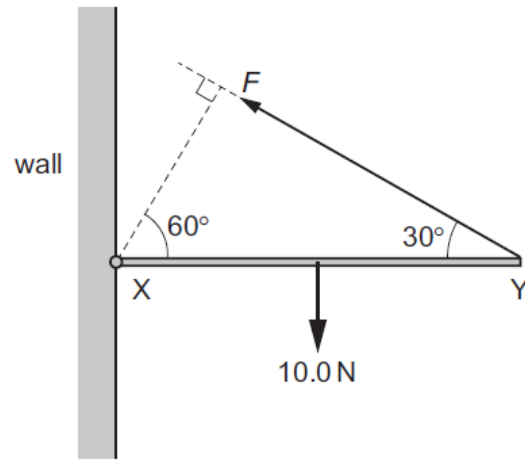


What is the moment of the force F about O?

- A $F \times \text{distance OX}$
- B $F \times \text{distance OY}$
- C $F \times \text{distance WO}$
- D $F \times \text{distance WX}$

7. June/2023/Paper_9702/12/No.12

A uniform rod XY of weight 10.0 N is freely hinged to a wall at X. It is held horizontal by a force F acting from Y at an angle of 30° to the horizontal, as shown.

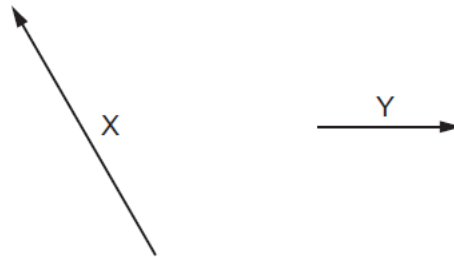


What is the value of F ?

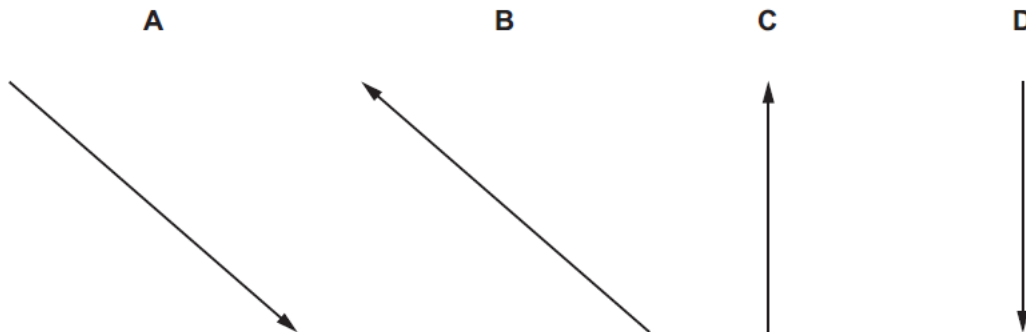
- A 5.0 N B 8.7 N C 10 N D 20 N

8. June/2023/Paper_9702/13/No.4

The diagram shows two vectors, X and Y, drawn to scale.



If $X = Y - Z$, which diagram represents the vector Z?



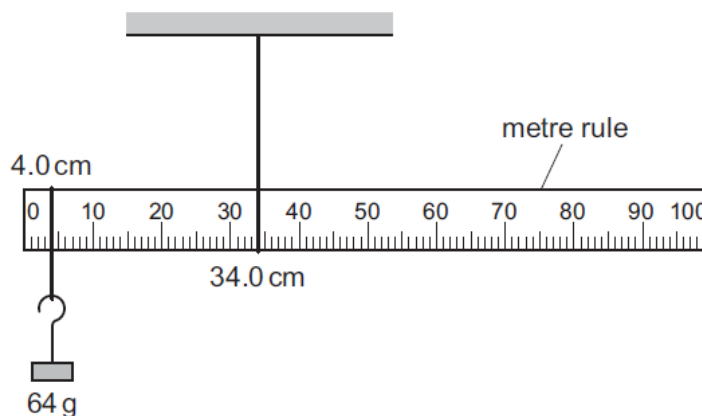
9. June/2023/Paper_9702/13/No.11

What is **not** a requirement for two forces to act as a couple?

- A The two forces act in opposite directions.
- B The two forces act through the same point.
- C The two forces combine to produce zero resultant force.
- D The two forces have equal magnitude.

10. June/2023/Paper_9702/13/No.12

A uniform metre rule is pivoted at the 34.0 cm mark, as shown.



The rule balances when a 64 g mass is hung from the 4.0 cm mark.

What is the mass of the metre rule?

- A 38 g
- B 44 g
- C 120 g
- D 136 g

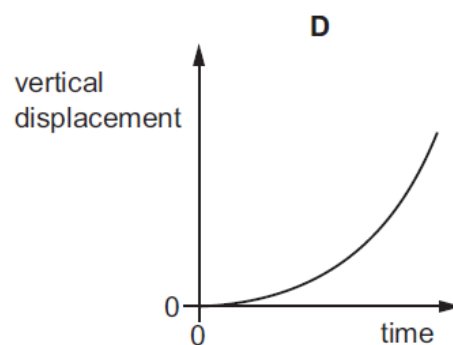
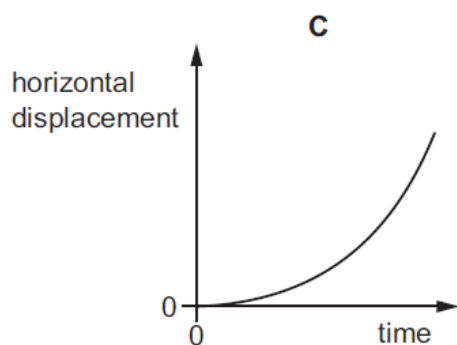
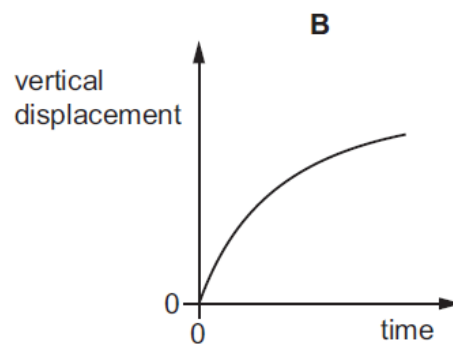
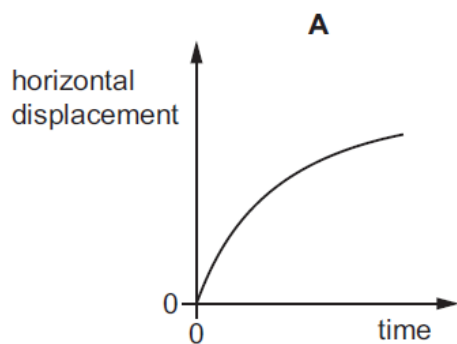
11. June/2023/Paper_9702/13/No.5

Which equation, representing uniformly accelerated motion in a straight line, can be determined using **only** the definition of acceleration?

- A $s = ut + \frac{1}{2}at^2$
- B $s = \frac{1}{2}(u+v)t$
- C $v = u + at$
- D $v^2 = u^2 + 2as$

An object moves from rest with uniform velocity horizontally and uniform acceleration vertically.

Which graph showing the variation with time of the displacement of the object from its initial position is correct?



A rigid uniform beam of weight W is connected to a fixed support by a hinge, as shown in Fig. 2.1.

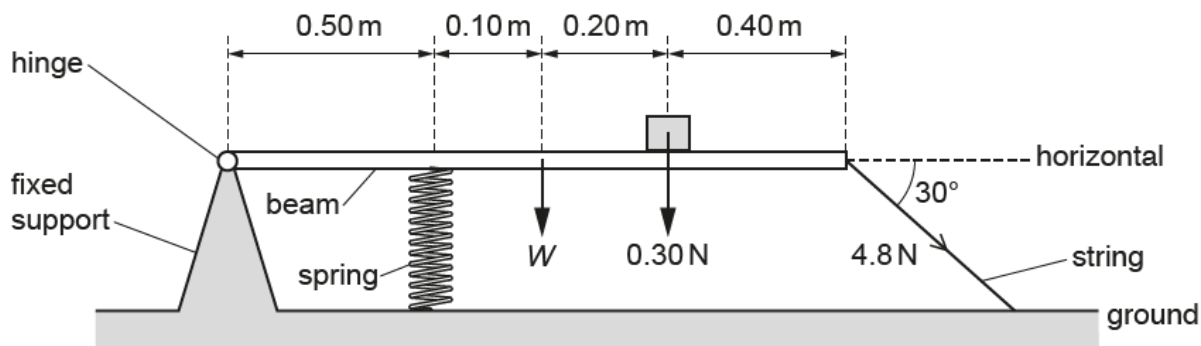


Fig. 2.1 (not to scale)

A compressed spring exerts a total force of 8.2 N vertically upwards on the horizontal beam. A block of weight 0.30 N rests on the beam. The right-hand end of the beam is connected to the ground by a string at an angle of 30° to the horizontal. The tension in the string is 4.8 N. The distances along the beam are shown in Fig. 2.1.

The beam is in equilibrium. Assume that the hinge is frictionless.

- (a) (i) Show that the vertical component of the tension in the string is 2.4 N.

[1]

- (ii) By taking moments about the hinge, determine the weight W of the beam.

$W = \dots\dots\dots$ N [3]

(iii) Calculate the horizontal component of the force exerted on the beam by the hinge.

force = ... N [1]

(b) The spring obeys Hooke's law and has an elastic potential energy of 0.32 J.

Calculate the compression of the spring.

compression = ... m [2]

- (a) State what is meant by the centre of gravity of an object.

.....
 [1]

- (b) Two blocks are on a horizontal beam that is pivoted at its centre of gravity, as shown in Fig. 2.1.

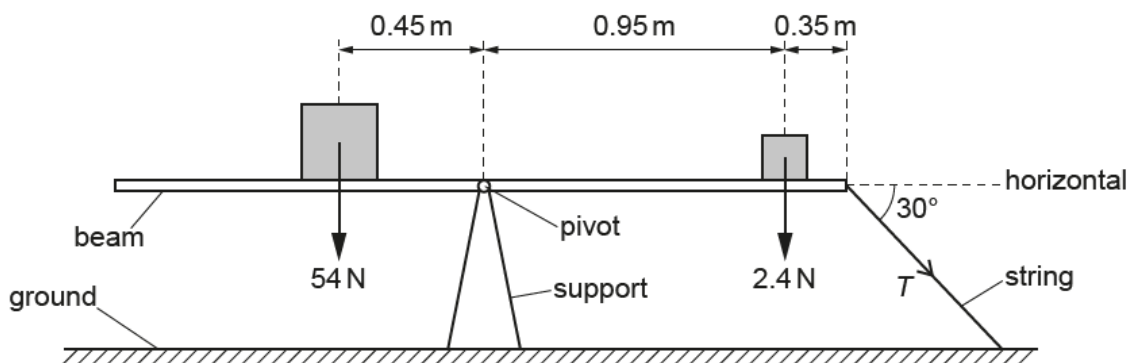


Fig. 2.1 (not to scale)

A large block of weight 54 N is a distance of 0.45 m from the pivot. A small block of weight 2.4 N is a distance of 0.95 m from the pivot and a distance of 0.35 m from the right-hand end of the beam.

The right-hand end of the beam is connected to the ground by a string that is at an angle of 30° to the horizontal. The beam is in equilibrium.

- (i) By taking moments about the pivot, calculate the tension T in the string.

$T = \dots\dots\dots$ N [3]

- (ii) The string is cut so that the beam is no longer in equilibrium.

Calculate the magnitude of the resultant moment about the pivot acting on the beam immediately after the string is cut.

resultant moment = $\dots\dots\dots$ Nm [1]

15. March/2023/Paper_9702/12/No.7

Which expression defines force?

- A $(\text{mass} \times \text{change in speed}) \times \text{time taken}$
- B $\frac{\text{mass} \times \text{change in speed}}{\text{time taken}}$
- C $(\text{change of momentum}) \times \text{time taken}$
- D $\frac{\text{change of momentum}}{\text{time taken}}$

16. March/2023/Paper_9702/12/No.8

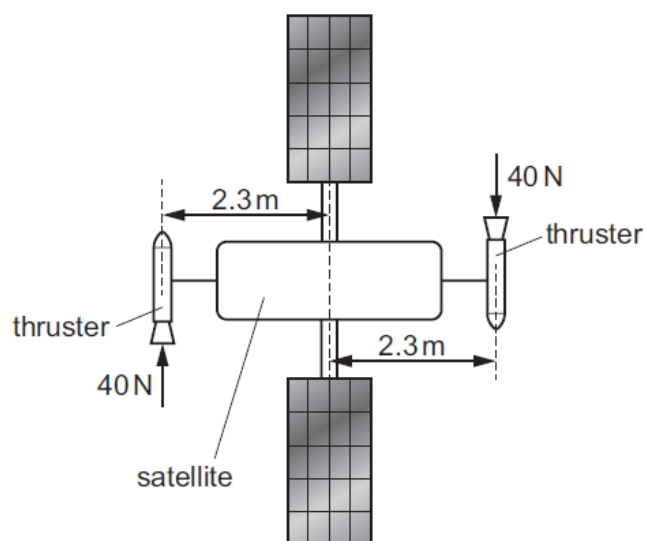
A ship of mass $8.4 \times 10^7 \text{ kg}$ is approaching a harbour with speed 16.4 ms^{-1} . By using reverse thrust it can maintain a constant total stopping force of $920\,000 \text{ N}$.

How long will it take to stop?

- A 15 seconds
- B 150 seconds
- C 25 minutes
- D 250 minutes

A satellite uses two thrusters to adjust its motion in space.

Each thruster exerts a force of 40 N on the satellite. The line of action of each force is a perpendicular distance of 2.3 m from the centre of gravity of the satellite. These two parallel forces act in opposite directions.

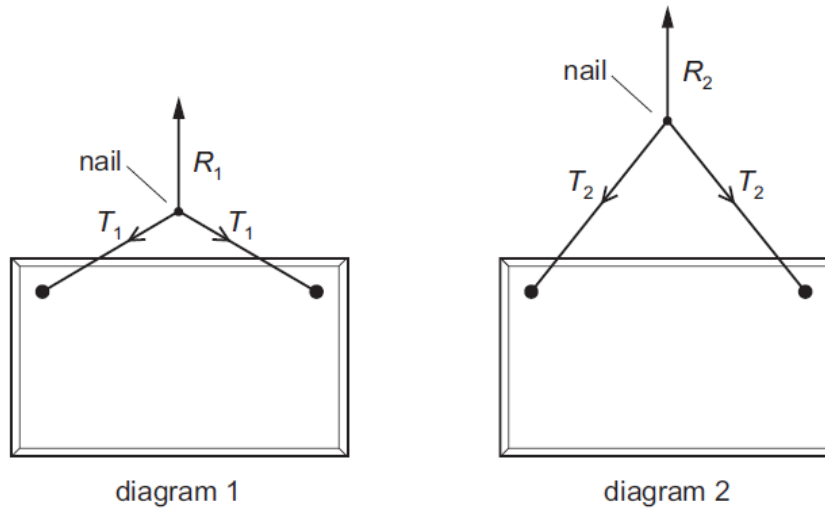


What are the magnitudes of the torque and the resultant force acting on the satellite due to the two thrust forces?

	torque / N m	resultant force / N
A	92	0
B	92	80
C	180	0
D	180	80

18. March/2023/Paper_9702/12/No.12

The diagrams show two ways of hanging the same picture.



In both cases, a string is attached to the same points on the picture and looped symmetrically over a nail in a wall. The forces shown are those that act on the nail.

In diagram 1, the string loop is shorter than in diagram 2.

Which information about the magnitude of the forces is correct?

- A $R_1 = R_2$ $T_1 = T_2$
- B $R_1 = R_2$ $T_1 > T_2$
- C $R_1 > R_2$ $T_1 < T_2$
- D $R_1 < R_2$ $T_1 = T_2$

19. March/2023/Paper_9702/12/No.15

What is the centre of gravity of an object?

- A the geometrical centre of the object
- B the point at which the weight of the object may be considered to act
- C the point on the object about which there is a zero net torque
- D the point where gravity acts on the object

A motor uses a wire to raise a block, as illustrated in Fig. 2.1.

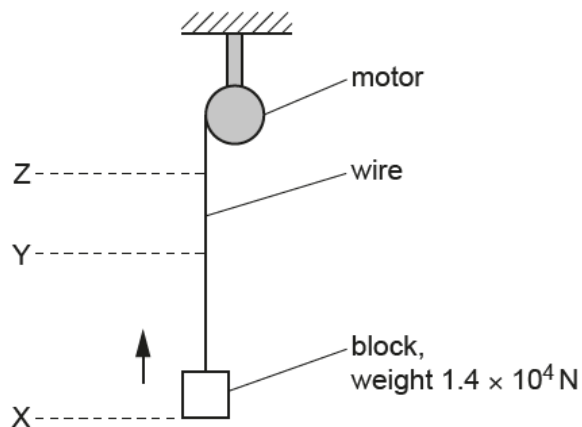


Fig. 2.1 (not to scale)

The base of the block takes a time of 0.49 s to move vertically upwards from level X to level Y at a constant speed of 0.64 ms^{-1} . During this time the wire has a strain of 0.0012 . The wire is made of metal of Young modulus $2.2 \times 10^{11} \text{ Pa}$ and has a uniform cross-section.

The block has a weight of $1.4 \times 10^4 \text{ N}$. Assume that the weight of the wire is negligible.

- (c) The base of the block now has a uniform deceleration of magnitude 1.3 ms^{-2} from level Y until the base of the block stops at level Z.

Calculate the tension T in the wire as the base of the block moves from Y to Z.

$$T = \dots\dots\dots \text{ N [3]}$$

A uniform beam AB is attached by a hinge to a wall at end A, as shown in Fig. 3.1.

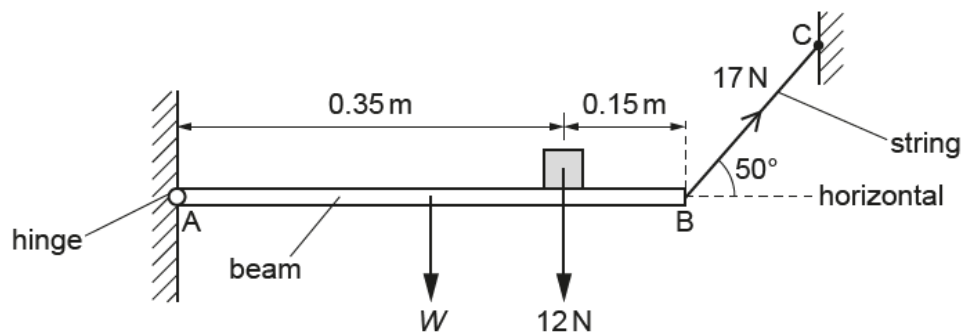


Fig. 3.1 (not to scale)

The beam has length 0.50 m and weight W . A block of weight 12 N rests on the beam at a distance of 0.15 m from end B.

The beam is held horizontal and in equilibrium by a string attached between end B and a fixed point C. The string has a tension of 17 N and is at an angle of 50° to the horizontal.

(a) State **two** conditions for an object to be in equilibrium.

- 1
- 2

[2]

(b) Show that the vertical component of the tension in the string is 13 N.

[1]

(c) By taking moments about end A, calculate the weight W of the beam.

$W = \dots\dots\dots$ N [2]

- (d) Calculate the magnitude of the vertical component of the force exerted on the beam by the hinge.

force = ... N [1]

- (e) The block is now moved closer to end A of the beam. Assume that the beam remains horizontal.

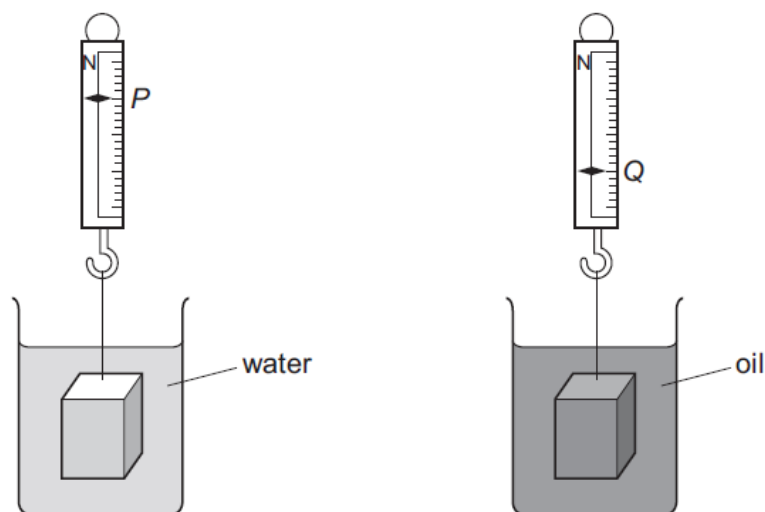
State whether this change will increase, decrease or have no effect on the horizontal component of the force exerted on the beam by the hinge.

..... [1]

[Total: 7]

1. Nov/2023/Paper_9702/11/No.14

An object of weight W is suspended from a newton meter. When the object is completely immersed in water, the newton meter reads P . When the object is completely immersed in oil, the newton meter reads Q .



What is the ratio $\frac{\text{density of oil}}{\text{density of water}}$?

A $\frac{W-P}{Q-P}$

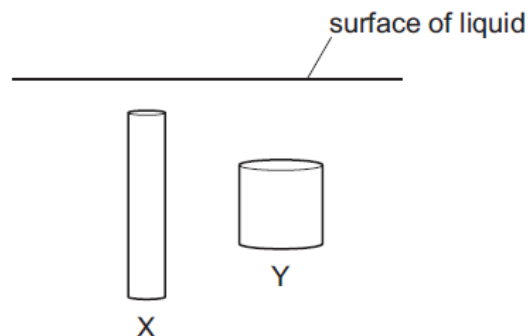
B $\frac{Q-P}{W-P}$

C $\frac{W-P}{W-Q}$

D $\frac{W-Q}{W-P}$

2. Nov/2023/Paper_ 9702/12/No.14

Two solid cylindrical objects X and Y are held fully submerged in a liquid, as shown.



The objects have the same volume. The density of the material of Y is twice the density of the material of X. Both objects are stationary.

Which statement is correct?

- A The force due to the liquid acting on the top surface of X is greater than that acting on the top surface of Y.
- B The pressure difference due to the liquid between the top and bottom surfaces of X is the same as that for Y.
- C The upthrust acting on X is the same as the upthrust acting on Y.
- D The weight of X is the same as the weight of Y.

3. Nov/2023/Paper_ 9702/13/No.14

Which expression for pressure is correct?

- A force per unit area
- B mass per unit area
- C mass per unit volume
- D weight per unit volume

4. Nov/2023/Paper_ 9702/13/No.13

Full-fat milk is made up of fat-free milk mixed with fat.

A volume of $1.000 \times 10^{-3} \text{ m}^3$ of full-fat milk has a mass of 1.035 kg. It contains 4.00% fat by volume.

The density of fat-free milk is $1.040 \times 10^3 \text{ kg m}^{-3}$.

What is the density of fat?

- A $1.25 \times 10^2 \text{ kg m}^{-3}$
- B $9.15 \times 10^2 \text{ kg m}^{-3}$
- C $9.28 \times 10^2 \text{ kg m}^{-3}$
- D $1.16 \times 10^3 \text{ kg m}^{-3}$

5. Nov/2023/Paper_ 9702/22/No.2(a)

A high-altitude balloon is stationary in still air. A solid sphere is suspended from the balloon by a string, as shown in Fig. 2.1.

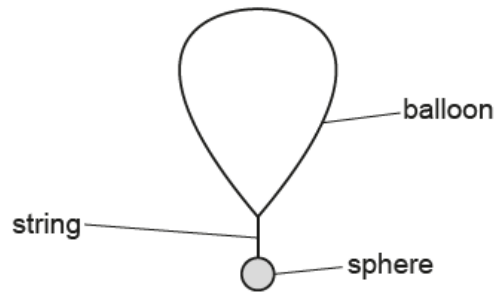


Fig. 2.1 (not to scale)

The volume of the balloon is 7.5 m^3 . The total weight of the balloon, string and sphere is 65 N . The upthrust acting on the string and sphere is negligible.

(a) Calculate the density of the air surrounding the balloon.

density = ... kg m^{-3} [2]

- (b) Fig. 3.1 shows an airship in flight. The airship is propelled by identical fans that can be angled to control the motion of the airship.

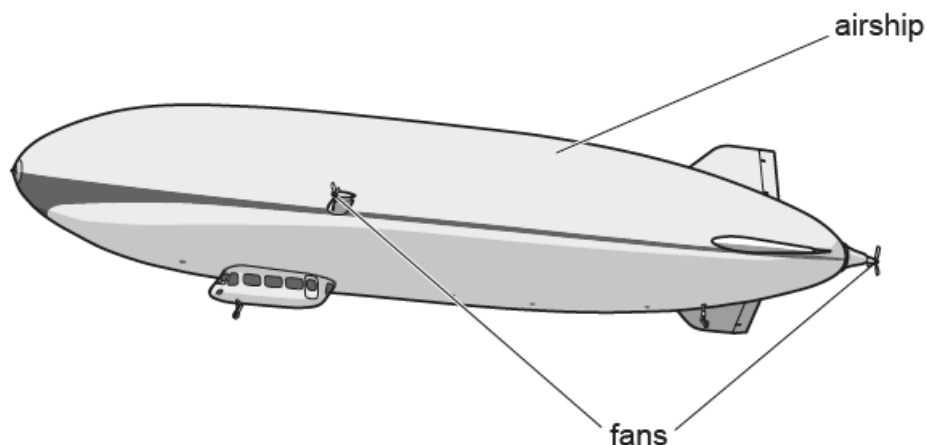


Fig. 3.1

The upthrust on the airship is 93 000 N.
The density of the surrounding air is 1.2 kg m^{-3} .

- (i) Calculate the volume of air displaced by the airship.

volume = ... m^3 [1]

- (ii) When fully loaded, the weight of the airship is greater than the upthrust.
To maintain horizontal flight, the fans provide a total vertical force of $3.0 \times 10^3 \text{ N}$ upwards on the airship.

Calculate the mass of the airship.

mass = ... kg [2]

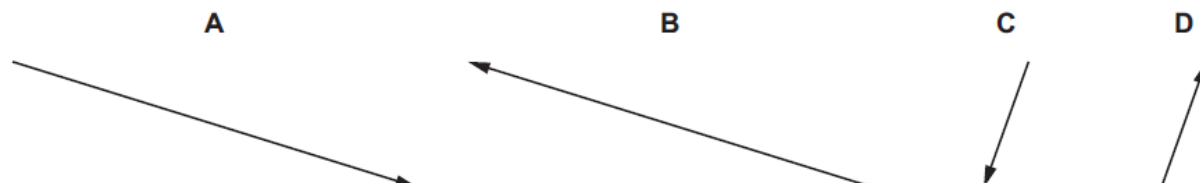
1. Nov/2023/Paper_ 9702/11/No.4

The diagram shows two coplanar forces, P and Q , drawn to scale.



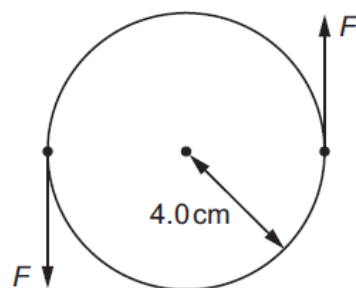
Force R is given by $R = Q - P$.

Which diagram represents R ?



2. Nov/2023/Paper_ 9702/11/No.11

A minimum torque of 20 N m must be applied to the lid of a jar for it to open. The radius of the lid is 4.0 cm .

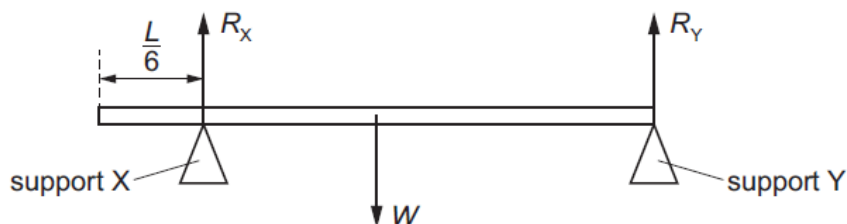


What is the minimum force F that must act on each side of the lid in order to open it?

- A** 2.5 N **B** 5.0 N **C** 250 N **D** 500 N

3. Nov/2023/Paper_ 9702/11/No.12

A uniform bar of length L and weight W rests horizontally on two supports X and Y.



Support X exerts a vertical force R_X at a distance of $\frac{L}{6}$ from one end of the bar.

Support Y exerts a vertical force R_Y at the other end of the bar.

The bar is in equilibrium.

What is the ratio $\frac{R_X}{R_Y}$?

A $\frac{3}{2}$

B $\frac{2}{3}$

C $\frac{3}{5}$

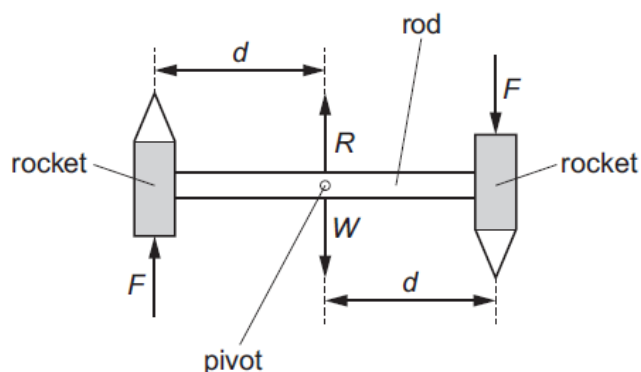
D $\frac{2}{5}$

4. Nov/2023/Paper_ 9702/11/No.13

A type of firework is made by connecting two rockets, facing in opposite directions, to a rod, as shown.

The rod is attached to a frictionless pivot so that the firework can rotate in a vertical plane.

The firework has weight W . The pivot exerts a force R on the rod that is equal and opposite to W .



Each rocket exerts a force of magnitude F on the rod at a perpendicular distance d from the pivot. The forces exerted by the rockets are always in opposite directions.

Air resistance is negligible.

Which statement is correct?

A The firework is in equilibrium because the resultant force acting on it is zero.

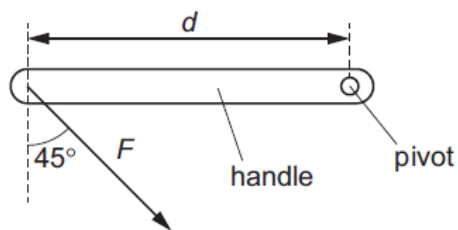
B The firework is in equilibrium because the resultant torque acting on it is zero.

C The firework is not in equilibrium because the resultant force acting on it is not zero.

D The firework is not in equilibrium because the resultant torque acting on it is not zero.

5. Nov/2023/Paper_ 9702/12/No.11

A force F is applied at an angle of 45° to a door handle at a distance d from the pivot of the handle, as shown.



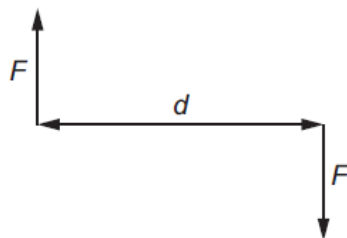
What is the moment of the force about the pivot?

- A $\frac{Fd}{\sqrt{2}}$ B Fd C $Fd\sqrt{2}$ D $2Fd$

6. Nov/2023/Paper_ 9702/12/No.12

A couple consists of two forces, each of magnitude F , that act in opposite directions in the same plane.

The perpendicular distance between the two forces is d .

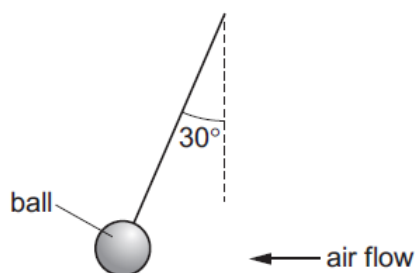


What is the torque of the couple?

- A $\frac{Fd}{2}$ B $\frac{F}{d}$ C Fd D $2Fd$

7. Nov/2023/Paper_ 9702/12/No.13

The diagram shows an experiment to determine the force exerted on a ball by a horizontal air flow.



The ball is suspended by a light string and weighs 0.15 N .

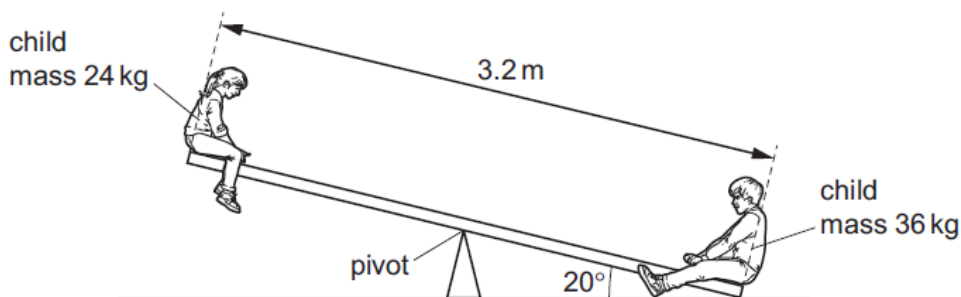
The deflection of the string from vertical is 30° . The ball is in equilibrium.

What is the force on the ball from the air flow?

- A** 0.075 N **B** 0.087 N **C** 0.26 N **D** 0.30 N

8. Nov/2023/Paper_ 9702/13/No.11

A uniform rigid beam of length 3.2 m is pivoted at its centre. Two children sit at the opposite ends of the beam, as shown.



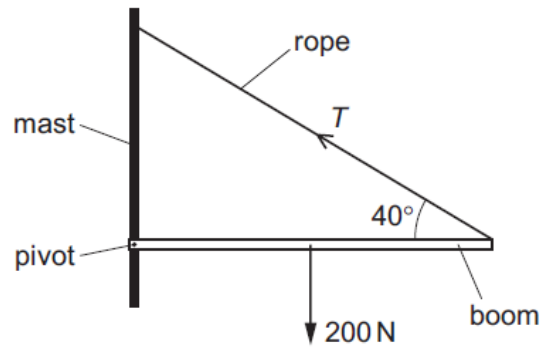
One child has a mass of 24 kg . The other child has a mass of 36 kg . The heavier child causes one end of the beam to permanently rest on the ground, so that the beam makes an angle of 20° to the horizontal ground.

What is the moment of the weight of the 24 kg child about the pivot?

- A** 72 Nm **B** 130 Nm **C** 350 Nm **D** 380 Nm

9. Nov/2023/Paper_ 9702/13/No.12

Two parts of a sailing boat are the mast and the boom. The mast is a vertical rigid beam and the boom is a horizontal rigid beam. One end of the boom is attached to the mast by a pivot. The other end of the boom is connected to the mast by a rope, as shown.



The rope is at an angle of 40° to the horizontal and exerts a tension force T on the boom. The weight of the boom is 200 N . The mass of the boom is uniformly distributed along its length. The boom is in equilibrium.

What is the magnitude of T ?

- A** 130 N **B** 160 N **C** 260 N **D** 310 N

A hot-air balloon floats just above the ground. The balloon is stationary and is held in place by a vertical rope, as shown in Fig. 2.1.

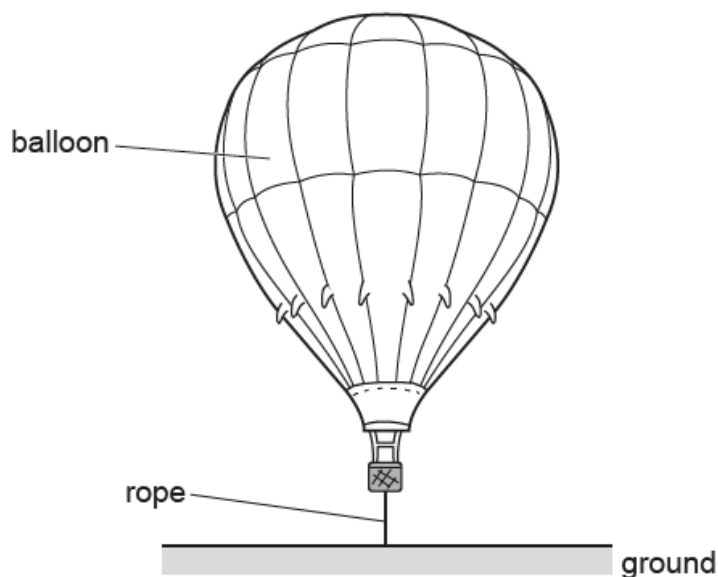


Fig. 2.1

The balloon has a weight W of $3.39 \times 10^4 \text{ N}$. The tension T in the rope is $4.00 \times 10^2 \text{ N}$.

Upthrust U acts on the balloon.

The density of the surrounding air is 1.23 kg m^{-3} .

- (a) (i) On Fig. 2.1, draw labelled arrows to show the directions of the three forces acting on the balloon. [2]
- (ii) Calculate the volume, to three significant figures, of the balloon.

volume = ... m^3 [3]

(iii) The balloon is released from the rope.

Calculate the initial acceleration of the balloon.

acceleration = ... ms^{-2} [3]

11. Nov/2023/Paper_ 9702/23/No.3(a)

(a) State the conditions for a system to be in equilibrium.

.....
.....
..... [2]