CAMBRIDGE INTERNATIONAL AS & A LEVEL PHYSICS · 9702

PHYSICS



EXAM QUESTION PACK

3 DYNAMICS

SCORE	PERCENTAGE
/	%

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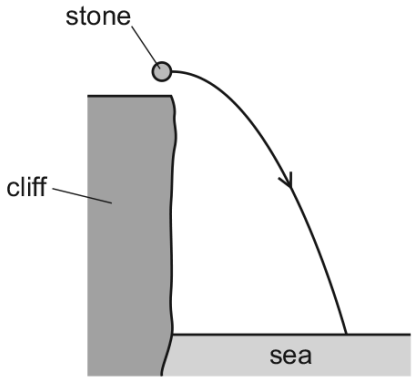
Chapter 4

Dynamics

4.1 Momentum and Newton's laws of motion

251. 9702_m20_qp_12 Q: 6

A stone is thrown horizontally from the top of a cliff and falls into the sea below. Air resistance is negligible. The path of the stone is shown.



In which direction does the resultant force on the stone act during its fall?

A horizontally to the right

B parallel to its velocity

C perpendicular to its velocity

D vertically downwards

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252. 9702_m20_qp_12 Q: 8

A person of mass 60 kg stands on accurate bathroom scales, placed on the floor of an elevator (lift) which operates in a tall building.

At a certain instant the bathroom scales read 58 kg.

Which row could give the person's direction of movement and type of motion?

	direction	motion
A	downwards	constant speed
B	downwards	slowing down
C	upwards	constant speed
D	upwards	slowing down

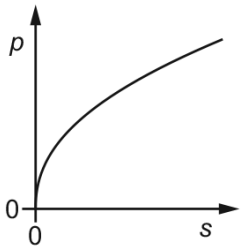
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253. 9702_s20_qp_11 Q: 8

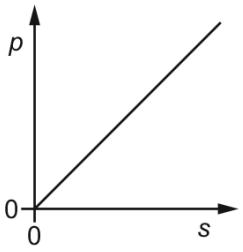
A car accelerates from rest in a straight line with constant acceleration.

Which graph best represents the variation of the momentum p of the car with the distance s travelled by the car?

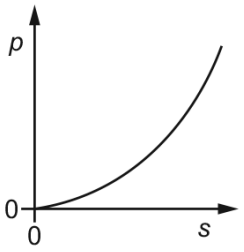
A



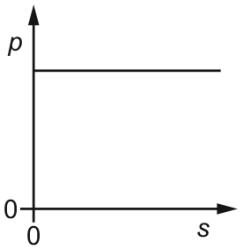
B



C



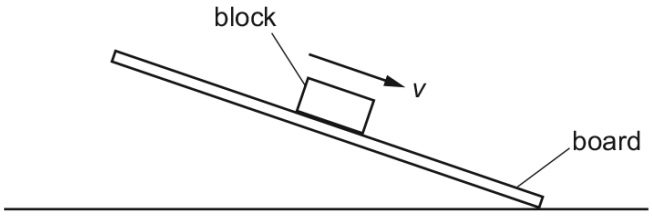
D



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254. 9702_s20_qp_11 Q: 11

A wooden block rests on the rough surface of a board. One end of the board is then raised until the block slides down the board at constant velocity *v*.



What describes the forces acting on the block when it is sliding with constant velocity?

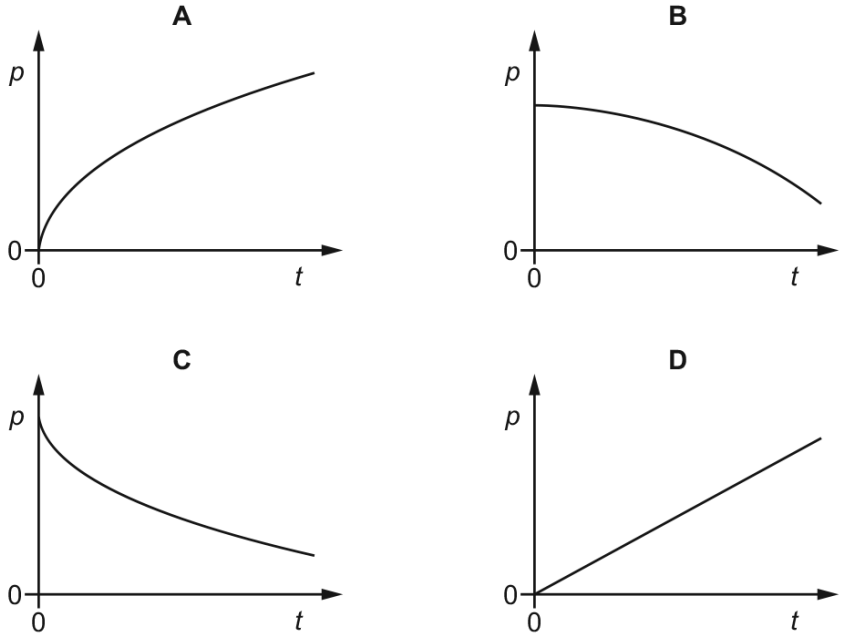
	frictional force on block	resultant force on block
A	down the board	down the board
B	down the board	zero
C	up the board	down the board
D	up the board	zero

---

255. 9702_s20_qp_12 Q: 7

The resultant force acting on an object is slowly increased.

Which graph could show the variation with time *t* of the momentum *p* of the object?



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256. 9702_s20_qp_13 Q: 8

A ball of mass m travels vertically downwards and then hits a horizontal floor at speed u.

It rebounds vertically upwards with speed v.

The collision lasts a time Δt.

What is the average resultant force exerted on the ball during the collision?

A $\frac{mv - mu}{\Delta t}$ downwards

B $\frac{mv - mu}{\Delta t}$ upwards

C $\frac{mv + mu}{\Delta t}$ downwards

D $\frac{mv + mu}{\Delta t}$ upwards

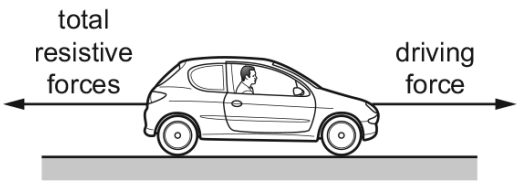
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257. 9702_s19_qp_11 Q: 9

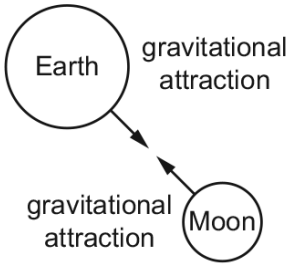
Each diagram illustrates a pair of forces of equal magnitude.

Which diagram gives an example of a pair of forces that is described by Newton's third law of motion?

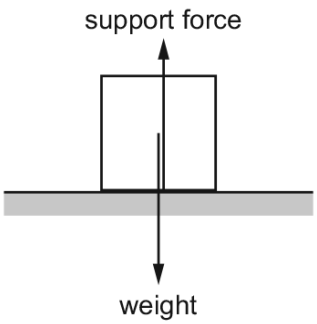
A



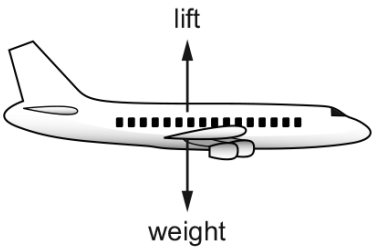
B



C



D



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258. 9702_s19_qp_12 Q: 9

What describes the mass of an object?

A the force the object experiences due to gravity

B the momentum of the object before a collision

C the resistance of the object to changes in motion

D the weight of the object as measured by a balance

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259. 9702_s19_qp_12 Q: 10

A car has mass *m*. A person needs to push the car with force *F* in order to give the car acceleration *a*. The person needs to push the car with force 2*F* in order to give the car acceleration 3*a*.

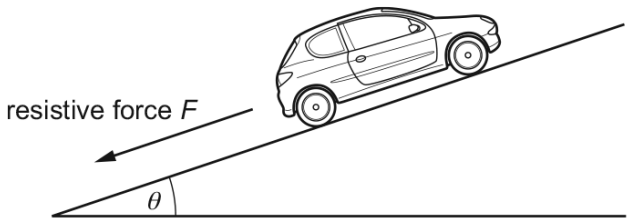
Which expression gives the constant resistive force opposing the motion of the car?

A *ma* **B** 2*ma* **C** 3*ma* **D** 4*ma*

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260. 9702_s19_qp_12 Q: 14

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*. The acceleration of free fall is *g*.



What is the force needed to propel the car at this constant speed?

A $mg \cos \theta$

B $mg \sin \theta$

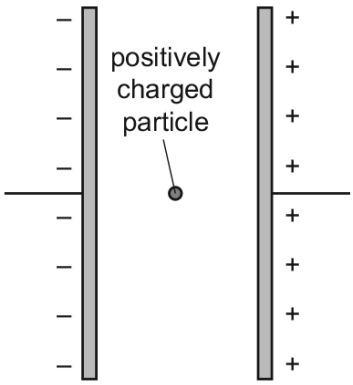
C $mg \cos \theta + F$

D $mg \sin \theta + F$

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261. 9702_s19_qp_13 Q: 10

A uniform electric field is created by two parallel vertical plates. A positively charged particle is in the vacuum between the plates, as shown.



Which statement is correct?

A The electric field makes the particle move towards the negative plate with a constant speed.

B The electric field makes the particle move towards the negative plate with a constant acceleration.

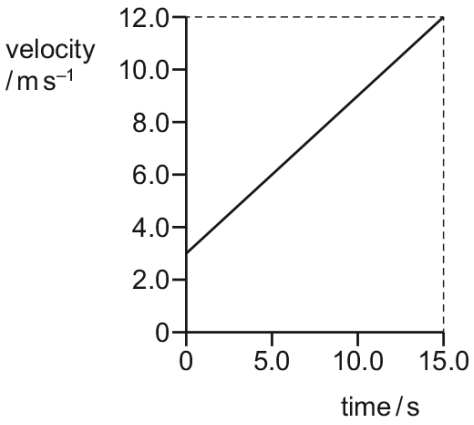
C The electric field produces a uniform rate of decrease in the particle's acceleration.

D The electric field produces a uniform rate of increase in the particle's acceleration.

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262. 9702_w19_qp_11 Q: 6

The velocity-time graph for an object of mass 2.5 kg is shown.



What is the resultant force acting on the object?

A 0.60 N **B** 0.80 N **C** 1.5 N **D** 2.0 N

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263. 9702_w19_qp_11 Q: 7

Which statement follows directly from Newton's first law?

A A body remains at constant velocity unless acted upon by a resultant force.

B A satellite in circular motion about the Earth has a constant velocity.

C A water drop leaving a spinning umbrella travels at a constant velocity.

D The force acting on an object is equal to its change in momentum.

---

264. 9702_w19_qp_11 Q: 8

A resultant force causes an object to accelerate.

What is equal to the resultant force?

A the acceleration of the object per unit mass

B the change in kinetic energy of the object per unit time

C the change in momentum of the object per unit time

D the change in velocity of the object per unit time

---

265. 9702_w19_qp_12 Q: 7

A snooker ball has a mass of 200 g. It hits the cushion of a snooker table and rebounds along its original path.

The ball arrives at the cushion with a speed of $14.0\,m\,s^{-1}$ and then leaves it with a speed of $7.0\,m\,s^{-1}$. The ball and the cushion are in contact for a time of 0.60 s.

What is the average force exerted on the ball by the cushion?

A 1.4 N **B** 2.3 N **C** 4.2 N **D** 7.0 N

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266. 9702_w19_qp_13 Q: 8

A snowflake is falling from the sky on a still day. Its weight acts vertically downwards and air resistance acts vertically upwards. As the snowflake falls, air resistance increases until it is equal to the weight and there is no resultant force acting on the snowflake.



When the forces become equal, which statement is correct?

A The snowflake accelerates.

B The snowflake decelerates.

C The snowflake is stationary.

D The snowflake moves at a constant velocity.

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267. 9702_m18_qp_12 Q: 7

A stone of mass m is dropped from a tall building. There is significant air resistance. The acceleration of free fall is g.

When the stone is falling at a constant (terminal) velocity, which information is correct?

	magnitude of the acceleration of the stone	magnitude of the force of gravity on the stone	magnitude of the force of air resistance on the stone
A	g	zero	mg
B	zero	mg	mg
C	zero	zero	mg
D	zero	mg	zero

---

268. 9702_m18_qp_12 Q: 10

Steel pellets, each with a mass of 0.60 g, fall vertically onto a horizontal plate at a rate of 100 pellets per minute. They strike the plate with a velocity of 5.0 m s^{-1} and rebound with a velocity of 4.0 m s^{-1}.

What is the average force exerted on the plate by the pellets?

A 0.0010 N **B** 0.0054 N **C** 0.0090 N **D** 0.54 N

---

269. 9702_s18_qp_11 Q: 8

The momentum of a car of mass m increases from p_1 to p_2.

What is the increase in the kinetic energy of the car?

A $\frac{(p_2^2 - p_1^2)}{2m}$ **B** $\frac{(p_2 - p_1)^2}{2m}$ **C** $\frac{p_2 - p_1}{2m}$ **D** $\frac{p_1 - p_2}{2m}$

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270. 9702_s18_qp_12 Q: 8

A tennis ball of mass 55 g is travelling horizontally with a speed of 30 m s^{-1}. The ball makes contact with a wall before rebounding in the horizontal direction with a speed of 20 m s^{-1}. The ball is in contact with the wall for a time of 5.0×10^{-3} s.

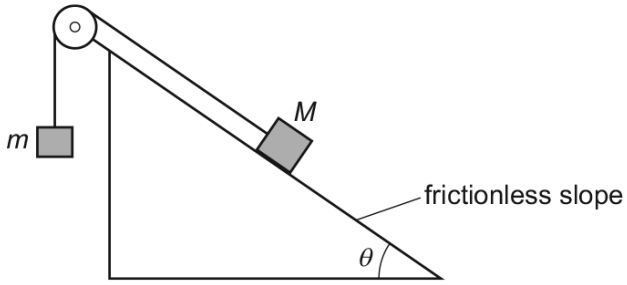
What is the average force exerted on the wall by the ball?

A 110 N **B** 220 N **C** 330 N **D** 550 N

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271. 9702_s18_qp_13 Q: 7

Two masses, M and m, are connected by an inextensible string which passes over a frictionless pulley. Mass M rests on a frictionless slope, as shown.



The slope is at an angle θ to the horizontal.

The two masses are initially held stationary and then released. Mass M moves down the slope.

Which expression **must** be correct?

A $\sin\theta < \frac{m}{M}$ **B** $\cos\theta < \frac{m}{M}$ **C** $\sin\theta > \frac{m}{M}$ **D** $\cos\theta > \frac{m}{M}$

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272. 9702_w18_qp_11 Q: 7

Water is pumped through a hose-pipe at a rate of 90 kg per minute. Water emerges horizontally from the hose-pipe with a speed of $20\,m\,s^{-1}$.

What is the minimum force required from a person holding the hose-pipe to prevent it moving backwards?

A 30 N **B** 270 N **C** 1800 N **D** 108 000 N

---

273. 9702_w18_qp_11 Q: 8

A ball of mass m is thrown vertically into the air. When the ball has speed v, the air resistance acting on the ball is F.

What is the magnitude of the acceleration of the ball when its speed is v as it rises and as it falls?

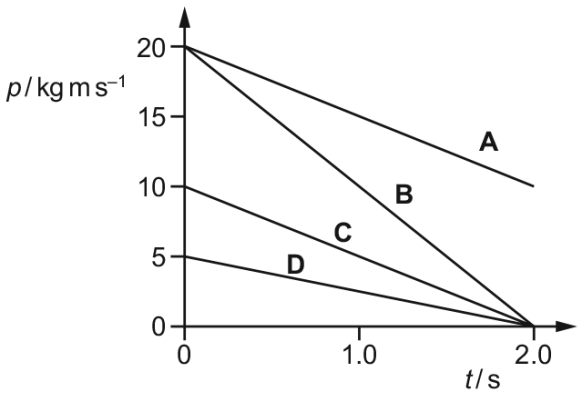
	acceleration when ball is rising	acceleration when ball is falling
A	$g - \frac{F}{m}$	$g - \frac{F}{m}$
B	$g - \frac{F}{m}$	$g + \frac{F}{m}$
C	$g + \frac{F}{m}$	$g - \frac{F}{m}$
D	$g + \frac{F}{m}$	$g + \frac{F}{m}$

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274. 9702_w18_qp_12 Q: 7

A resultant force of 10 N acts on a body for a time of 2.0 s.

Which graph could show the variation with time t of the momentum p of the body?



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275. 9702_w18_qp_13 Q: 7

Two isolated spheres have masses 2.0 kg and 4.0 kg. The spheres collide and then move apart.

During the collision, the 2.0 kg mass has an average acceleration of $8.0\,m\,s^{-2}$.

What is the average acceleration of the 4.0 kg mass?

A $2.0\,m\,s^{-2}$ **B** $4.0\,m\,s^{-2}$ **C** $8.0\,m\,s^{-2}$ **D** $16\,m\,s^{-2}$

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276. 9702_w18_qp_13 Q: 8

A mass is placed on a frictionless slope inclined at 30° to the horizontal. The mass is then released.

What is its acceleration down the slope?

A $4.9\,m\,s^{-2}$ **B** $5.7\,m\,s^{-2}$ **C** $8.5\,m\,s^{-2}$ **D** $9.8\,m\,s^{-2}$

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277. 9702_w18_qp_13 Q: 10

A ship of mass 8.4×10^7 kg is approaching a harbour with speed $16.4\,m\,s^{-1}$. By using reverse thrust it can maintain a constant total stopping force of 920 000 N.

How long will it take to stop?

A 15 seconds

B 150 seconds

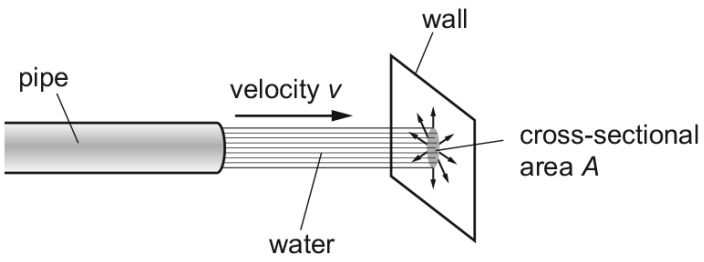
C 25 minutes

D 250 minutes

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278. 9702_m17_qp_12 Q: 9

Water flows out of a pipe and hits a wall.



When the jet of water hits the wall, it has horizontal velocity v and cross-sectional area A.

The density of the water is ρ. The water does not rebound from the wall.

What is the force exerted on the wall by the water?

A $\frac{\rho v}{A}$ **B** $\frac{\rho v^2}{A}$ **C** $\rho A v$ **D** $\rho A v^2$

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279. 9702_s17_qp_11 Q: 7

The mass of a rocket-propelled truck is approximately equal to the mass of the fuel in its tank. The fuel is ignited and the truck is propelled along horizontal tracks by a constant force. The effect of air resistance is negligible.

During a test run the fuel is consumed at a constant rate.

Which statement describes the acceleration of the truck during the test run?

A The acceleration of the truck decreases as the fuel is consumed.

B The acceleration of the truck increases as the fuel is consumed.

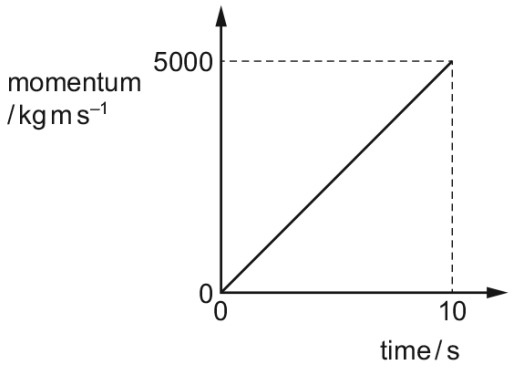
C The acceleration of the truck remains constant.

D The acceleration of the truck is zero and the truck moves at a constant velocity.

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280. 9702_s17_qp_11 Q: 10

The graph shows how the momentum of a motorcycle changes with time.



What is the resultant force on the motorcycle?

A 500 N **B** 5000 N **C** 25 000 N **D** 50 000 N

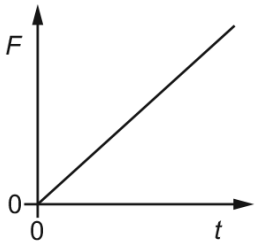
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281. 9702_s17_qp_12 Q: 7

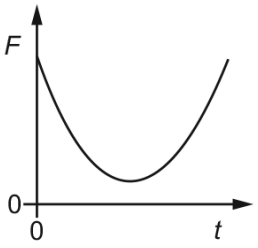
A rubber ball is dropped onto a table and bounces back up. The table exerts a force *F* on the ball.

Which graph best shows the variation with time *t* of the force *F* for the short time that the ball is in contact with the table?

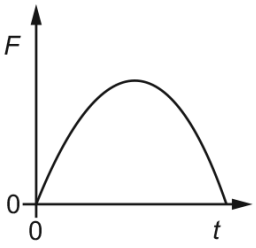
A



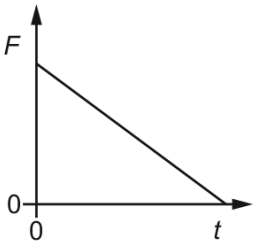
B



C



D



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282. 9702_s17_qp_12 Q: 8

A golf ball of mass m is dropped onto a hard surface from a height h_1 and rebounds to a height h_2.

The momentum of the golf ball just as it reaches the surface is different from its momentum just as it leaves the surface.

What is the total change in the momentum of the golf ball between these two instants? (Ignore air resistance.)

A $m\sqrt{2gh_1} - m\sqrt{2gh_2}$

B $m\sqrt{2gh_1} + m\sqrt{2gh_2}$

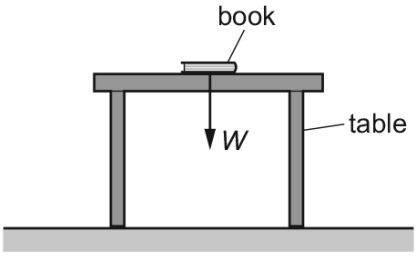
C $m\sqrt{2g(h_1 - h_2)}$

D $m\sqrt{2g(h_1 + h_2)}$

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283. 9702_s17_qp_12 Q: 9

A book of weight W is at rest on a table. A student attempts to state Newton's third law of motion by saying that 'action equals reaction'.



If the weight of the book is the 'action' force, what is the 'reaction' force?

A the force W acting downwards on the Earth from the table

B the force W acting upwards on the book from the table

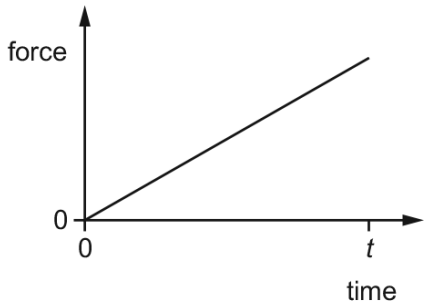
C the force W acting upwards on the Earth from the book

D the force W acting upwards on the table from the floor

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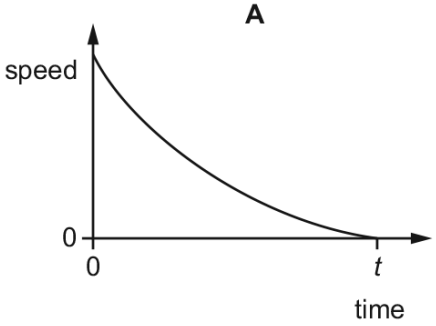
284. 9702_s17_qp_13 Q: 7

A driver stops his car in time t by gradually increasing the total braking force on the car. The graph shows the resultant force on the car.

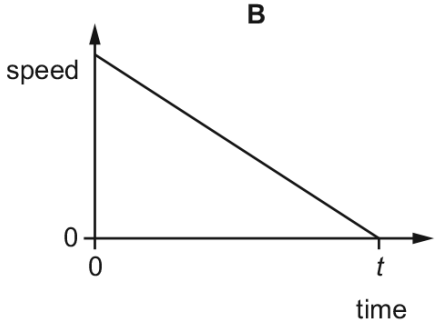


Which graph shows how the speed of the car will vary during this time?

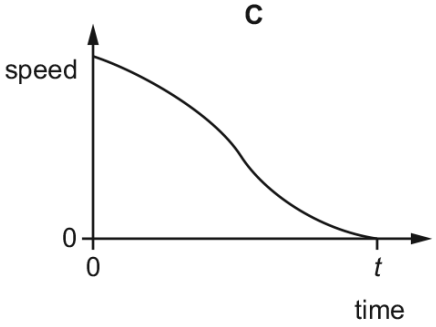
A



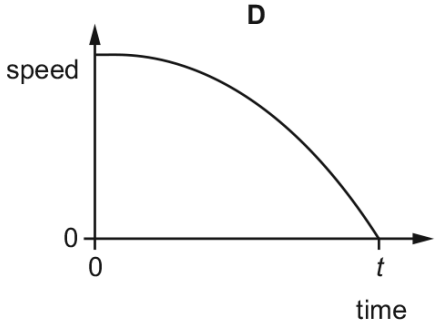
B



C



D



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285. 9702_s17_qp_13 Q: 9

A ball of mass 2.0 kg travels horizontally with a speed of 4.0 m s^{-1}. The ball collides with a wall and rebounds in the opposite direction with a speed of 2.8 m s^{-1}. The time of the collision is 150 ms.

What is the average force exerted on the wall?

A 16 N **B** 37 N **C** 53 N **D** 91 N

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286. 9702_s17_qp_13 Q: 10

An ice-hockey puck of mass 150 g moves with an initial speed of 2.0 m s^{-1} along the surface of an ice rink.

The puck slides a distance of 30 m in a straight line before stopping.

What is the average frictional force acting on the puck?

A 0.010 N **B** 0.020 N **C** 0.067 N **D** 0.44 N

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287. 9702_s17_qp_13 Q: 16

A constant force pushes a block along a horizontal frictionless surface. The block moves from rest through a fixed distance.

What is the relationship between the final speed v of the block and its mass m?

A $\sqrt{v} \propto \frac{1}{m}$ **B** $v \propto \sqrt{m}$ **C** $v \propto \frac{1}{\sqrt{m}}$ **D** $\sqrt{v} \propto m$

---

288. 9702_w17_qp_11 Q: 9

A car is moving at constant speed in a straight line with the engine providing a driving force equal to the resistive force F.

When the engine is switched off, the car is brought to rest in a distance of 100 m by the resistive force.

It may be assumed that F is constant during the deceleration.

The process is then repeated for the same car with the same initial speed but with a constant resistive force of 0.800 F.

How far will the car travel while decelerating?

A 120 m **B** 125 m **C** 156 m **D** 250 m

---

289. 9702_w17_qp_11 Q: 10

What is a statement of the principle of conservation of momentum?

A In an elastic collision momentum is constant.

B Momentum is the product of mass and velocity.

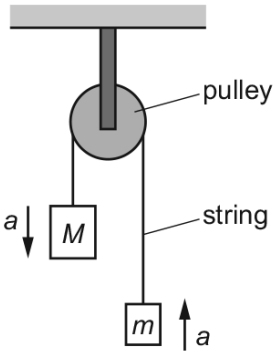
C The force acting on a body is proportional to its rate of change of momentum.

D The momentum of an isolated system is constant.

---

290. 9702_w17_qp_12 Q: 10

Two blocks of masses M and m are joined by a thin string which passes over a frictionless pulley, as shown.



The acceleration of free fall is g.

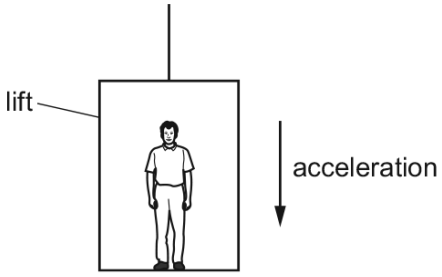
What is the acceleration a of the two blocks?

A $\frac{(M+m)}{(M-m)}g$ **B** $\frac{(M-m)}{(M+m)}g$ **C** $\frac{M}{m}g$ **D** $\frac{m}{M}g$

---

291. 9702_w17_qp_13 Q: 8

A man stands in a lift that is accelerating vertically downwards, as shown.



Which statement describes the force exerted by the man on the floor?

A It is equal to the weight of the man.

B It is greater than the force exerted by the floor on the man.

C It is less than the force exerted by the floor on the man.

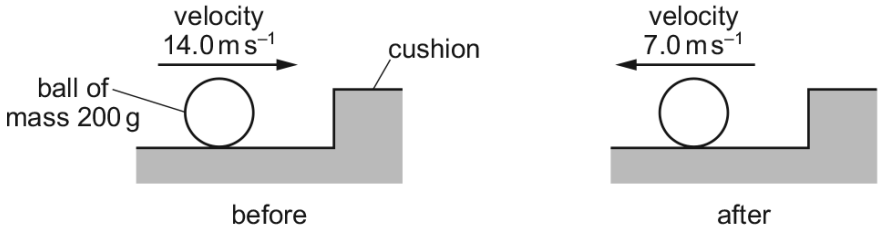
D It is less than the weight of the man.

---

292. 9702_w17_qp_13 Q: 9

A snooker ball of mass 200 g hits the cushion of a snooker table at right-angles with a speed of $14.0\,m\,s^{-1}$.

The ball rebounds with half of its initial speed. The ball is in contact with the cushion for 0.60 s.



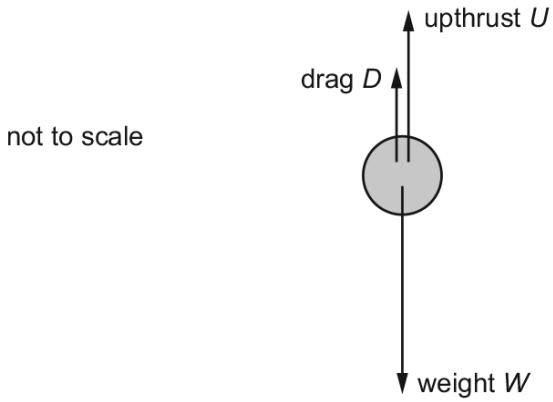
What is the average force exerted on the ball by the cushion?

A 2.3 N **B** 7.0 N **C** 2300 N **D** 7000 N

---

293. 9702_w17_qp_13 Q: 13

A solid sphere falls at constant (terminal) velocity in a liquid. The three forces acting on the sphere are shown in the diagram.



How are the three forces related?

A $W + D = U$

B $W > U + D$

C $W - U = D$

D $W < D + U$

---

294. 9702_m16_qp_12 Q: 9

Which statement **defines** force?

A When a force acts on a body that is free to move, the force is the product of the mass of the body and its acceleration.

B When a force acts on a body that is free to move, the force is the rate of change of momentum of the body.

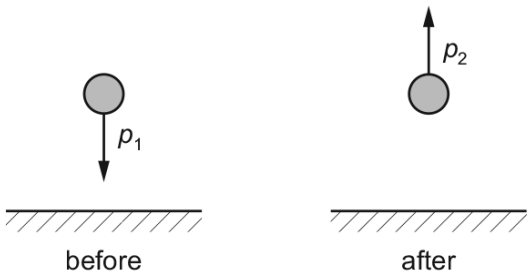
C When a force acts on a body that is free to move, the force is the work done by the force divided by the distance moved by the body.

D When a force acts on a lever and causes a moment, the force is the moment divided by the perpendicular distance of the force from the pivot.

---

295. 9702_s16_qp_12 Q: 9

A ball falls vertically onto horizontal ground and rebounds, as shown.



The ball has momentum p_1 downwards just before hitting the ground. After rebounding, the ball leaves the ground with momentum p_2 upwards. The ball is in contact with the ground for 0.020 s. During this time interval, an average resultant force of 25 N acts on the ball.

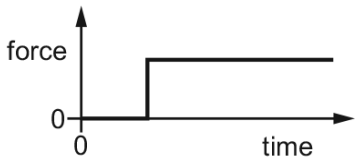
What is a possible combination of values for p_1 and p_2?

	p_1 / kg m s^{-1}	p_2 / kg m s^{-1}
A	0.15	0.65
B	0.20	0.30
C	0.30	0.20
D	0.65	0.15

---

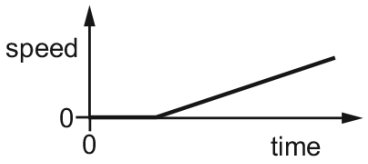
296. 9702_w16_qp_11 Q: 9

A car is stationary at traffic lights. When the traffic lights change to green, the driver presses down sharply on the accelerator. The resultant horizontal force acting on the car varies with time as shown.

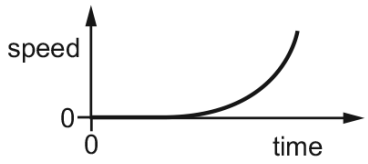


Which graph shows the variation with time of the speed of the car?

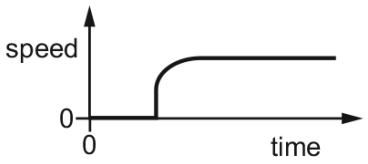
A



B



C



D



---

297. 9702_w16_qp_11 Q: 11

A car has mass m. A person needs to push the car with force F in order to give the car acceleration a. The person needs to push the car with force $2F$ in order to give the car acceleration $3a$.

Which expression gives the constant resistive force opposing the motion of the car?

A ma **B** $2ma$ **C** $3ma$ **D** $4ma$

---

298. 9702_w16_qp_12 Q: 12

A bullet of mass 8.0 g travels at a speed of 300 $m\,s^{-1}$. The bullet hits a target and stops after a time of 100 μs.

What is the average force exerted by the target on the bullet?

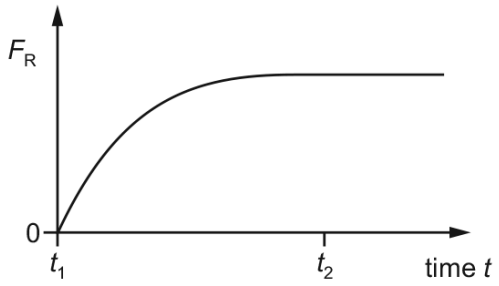
A 24 N **B** 240 N **C** 2400 N **D** 24 000 N

---

299. 9702_w16_qp_12 Q: 13

A light ball is falling vertically through air.

The variation with time t of the resistive force F_R acting on the ball is shown.

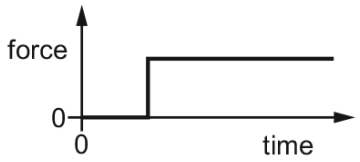


At which times are the speed of the ball zero, the speed at a maximum and the acceleration zero?

	zero speed	maximum speed	zero acceleration
A	t_1	t_2	t_1
B	t_1	t_2	t_2
C	t_2	t_1	t_1
D	t_2	t_1	t_2

300. 9702_w16_qp_13 Q: 9

A car is stationary at traffic lights. When the traffic lights change to green, the driver presses down sharply on the accelerator. The resultant horizontal force acting on the car varies with time as shown.

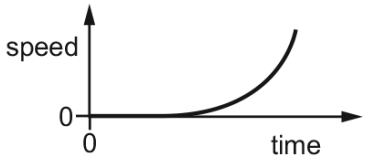


Which graph shows the variation with time of the speed of the car?

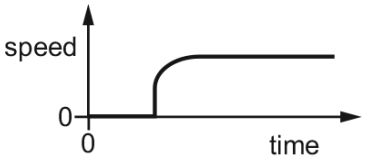
A



B



C



D



---

301. 9702_w16_qp_13 Q: 11

A car has mass m. A person needs to push the car with force F in order to give the car acceleration a. The person needs to push the car with force $2F$ in order to give the car acceleration $3a$.

Which expression gives the constant resistive force opposing the motion of the car?

A ma **B** $2ma$ **C** $3ma$ **D** $4ma$

---

302. 9702_s15_qp_11 Q: 14

What is the **definition** of the force on a body?

A the mass of the body multiplied by its acceleration

B the power input to the body divided by its velocity

C the rate of change of momentum of the body

D the work done on the body divided by its displacement

---

303. 9702_s15_qp_12 Q: 10

A firework rocket is fired vertically upwards. The fuel burns and produces a constant upwards force on the rocket. After 5 seconds there is no fuel left. Air resistance is negligible.

What is the acceleration before and after 5 seconds?

	before 5 seconds	after 5 seconds
A	constant	constant
B	constant	zero
C	increasing	constant
D	increasing	zero

---

304. 9702_s15_qp_12 Q: 13

Newton's third law of motion is often summarised as 'Every action (force) has an equal and opposite reaction.'

A book rests on a table.

If the weight of the book is the 'action' force, what is the 'reaction' force?

A the pull of the book on the Earth

B the pull of the Earth on the book

C the push of the book on the table

D the push of the table on the book

4.2 Non-uniform motion

305. 9702_s20_qp_11 Q: 9

The resultant force F on a raindrop of mass m falling with velocity v is given by the equation

$$F = mg - kv^2$$

where k is a constant and g is the acceleration of free fall.

What is the velocity of the raindrop when it reaches a constant (terminal) velocity?

A $\sqrt{\frac{k}{mg}}$ **B** $\frac{k}{mg}$ **C** $\sqrt{\frac{mg}{k}}$ **D** $\frac{mg}{k}$

---

306. 9702_s20_qp_12 Q: 8

An astronaut has a weight of 660 N when she is standing on the Earth's surface.

The acceleration of free fall on the surface of Mars is $3.71\,\text{m}\,\text{s}^{-2}$.

What would be the weight of the astronaut if she stood on the surface of Mars?

A 67.3 N **B** 178 N **C** 250 N **D** 660 N

---

307. 9702_s20_qp_13 Q: 9

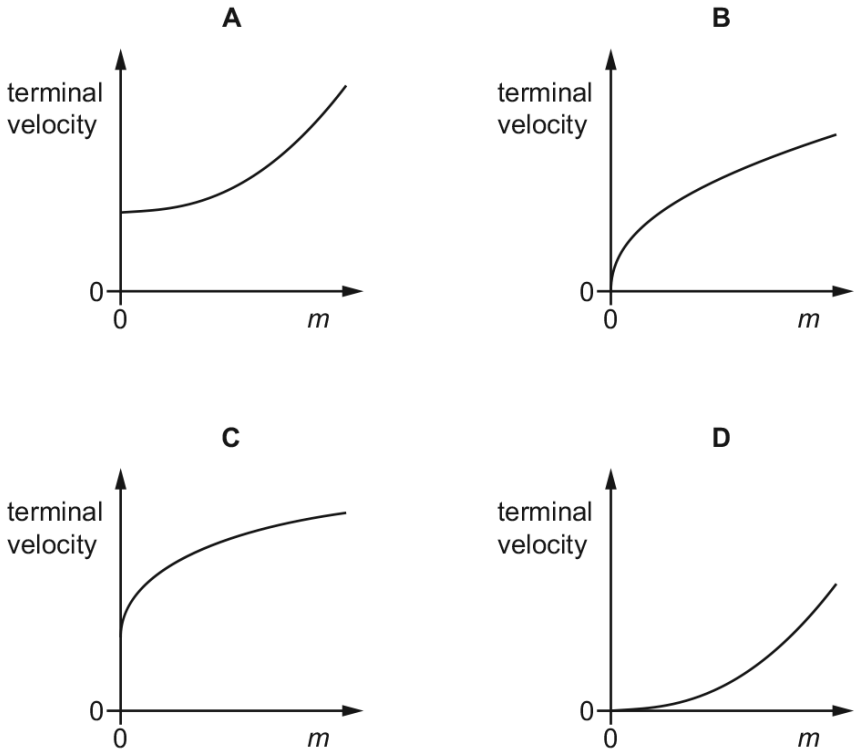
The resultant force F on a raindrop of mass m falling vertically with velocity v is given by the equation

$$F = mg - kv^2$$

where k is a constant and g is the acceleration of free fall.

The falling raindrop eventually reaches a constant (terminal) velocity.

Which graph shows the variation of the terminal velocity of the raindrop with mass m?



---

308. 9702_m19_qp_12 Q: 7

A stone is thrown vertically upwards from a point that is 12 m above the sea. It then falls into the sea below after 3.4 s.

Air resistance is negligible.

At which speed was the stone released when it was thrown?

A $3.5\,m\,s^{-1}$ **B** $6.6\,m\,s^{-1}$ **C** $13\,m\,s^{-1}$ **D** $20\,m\,s^{-1}$

---

309. 9702_m19_qp_12 Q: 9

In the absence of air resistance, a ball thrown horizontally from a tower with velocity v, will land after time T seconds.

If, however, air resistance is taken into account, which statement is correct?

A The ball lands with a horizontal velocity less than v after more than T seconds.

B The ball lands with a horizontal velocity less than v after T seconds.

C The ball lands with a horizontal velocity v after more than T seconds.

D The ball lands with a horizontal velocity v after T seconds.

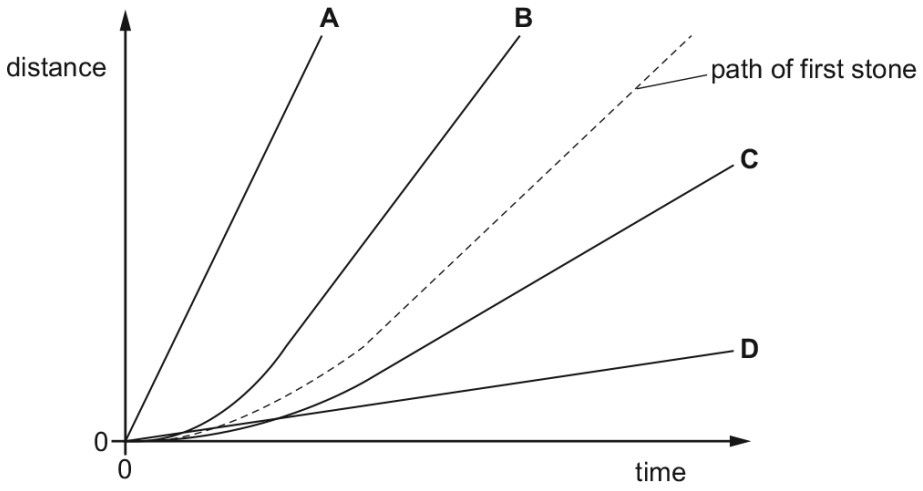
---

310. 9702_s19_qp_11 Q: 10

A stone is dropped from a tall building. Air resistance is significant. The variation of distance fallen with time is shown by the dashed line.

A second stone with the same dimensions but a smaller mass is dropped from the same building.

Which line represents the motion of the second stone?

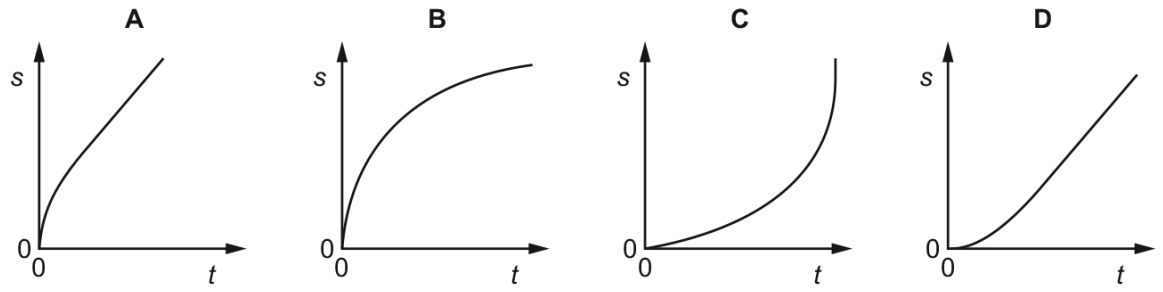


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311. 9702_w19_qp_12 Q: 8

A tennis ball is released from rest at time $t = 0$ and falls through air for a long time.

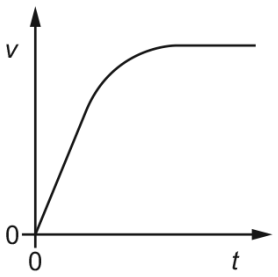
Which graph of its displacement s against time t best represents the motion of the ball?



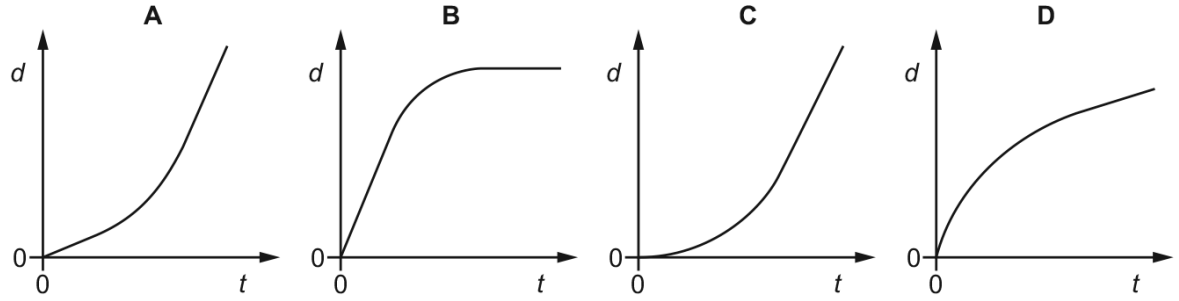
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312. 9702_s18_qp_12 Q: 7

A sky-diver falls vertically from a helicopter and reaches constant (terminal) velocity. The graph shows the variation with time t of the speed v of the sky-diver.



Which graph shows the variation with time t of the distance d fallen by the sky-diver?

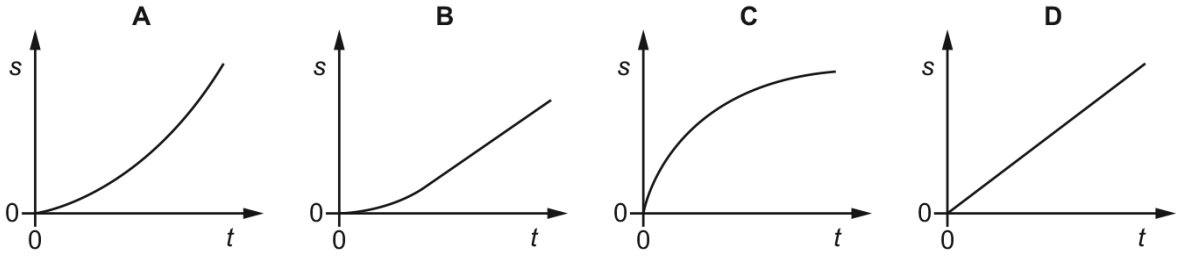


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313. 9702_s18_qp_13 Q: 8

A sky-diver falls from a stationary balloon at time $t = 0$. As the sky-diver falls, her speed and the air resistance increase until the force of the air resistance is equal to her weight.

Which graph best shows the variation with time t of the displacement s for the motion of the sky-diver?



---

314. 9702_w18_qp_12 Q: 8

The acceleration of free fall on the surface of planet P is one tenth of that on the surface of planet Q.

On the surface of P, a body has a mass of 1.0 kg and a weight of 1.0 N.

What are the mass and the weight of the same body on the surface of planet Q?

	mass on Q / kg	weight on Q / N
A	1.0	0.1
B	1.0	10
C	10	10
D	10	100

---

315. 9702_m17_qp_12 Q: 8

The acceleration of free fall on Pluto is 0.66 m s^{-2}.

An object weighs 6.0 N on Earth.

What would this object weigh on Pluto?

A 0.40 N **B** 0.93 N **C** 4.0 N **D** 39 N

---

316. 9702_s17_qp_11 Q: 8

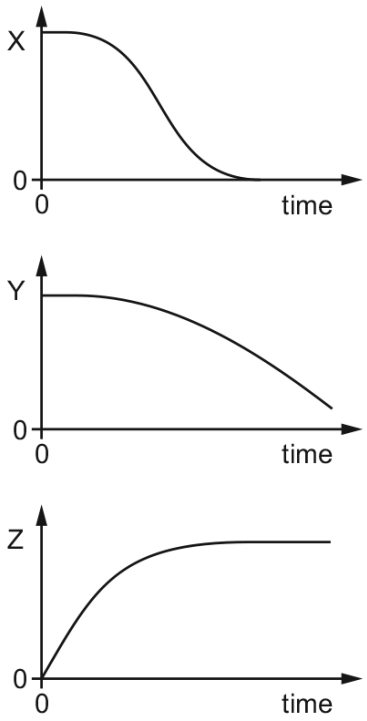
An object is dropped at time $t = 0$ from a high building. Air resistance is significant.

Three graphs are plotted against time.

the height of the object above the ground

the speed of the object

the magnitude of the resultant force on the object

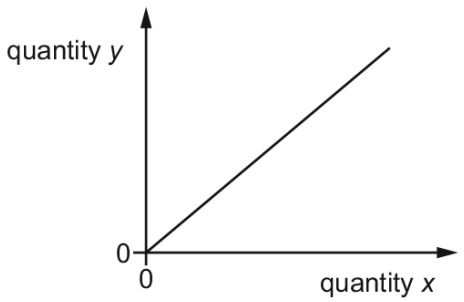


What are the quantities X, Y and Z?

	height of the object above the ground	speed of the object	magnitude of the resultant force on the object
A	X	Y	Z
B	X	Z	Y
C	Y	Z	X
D	Z	Y	X

317. 9702_s17_qp_13 Q: 8

The graph shows the variation of a quantity y with a quantity x for a body that is falling in air at constant (terminal) velocity in a uniform gravitational field.

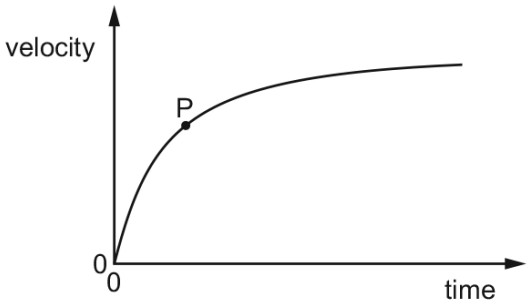


Which quantities could x and y represent?

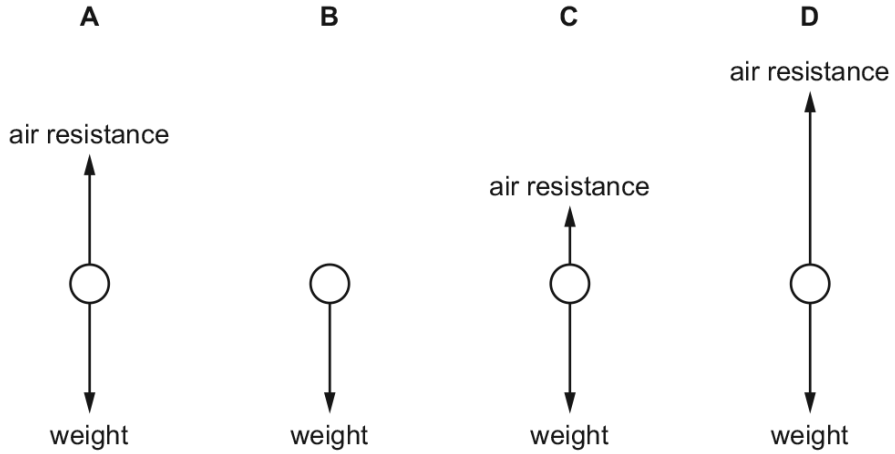
	x	y
A	air resistance	acceleration
B	loss of height	gain in kinetic energy
C	loss of potential energy	work done against air resistance
D	time	velocity

318. 9702_s16_qp_12 Q: 10

A sphere falls from rest through the air. The graph shows the variation with time of the sphere's velocity.



Which diagram shows the forces acting on the sphere when it is at the velocity corresponding to point P on the graph?

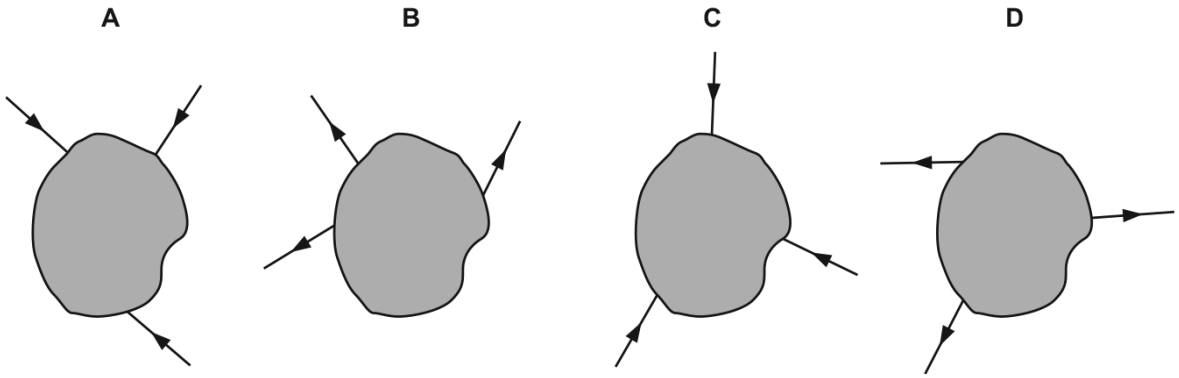


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319. 9702_s16_qp_13 Q: 12

Three coplanar forces act on an object in the directions shown.

In which diagram could the object be in equilibrium?



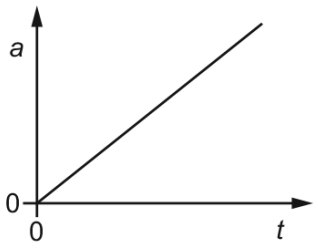
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320. 9702_w16_qp_11 Q: 10

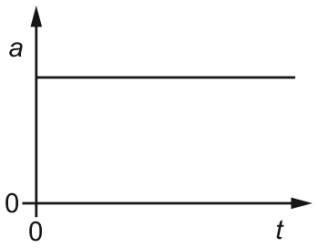
A beach-ball falls vertically from a high hotel window. Air resistance is **not** negligible.

Which graph shows the variation with time *t* of the acceleration *a* of the ball?

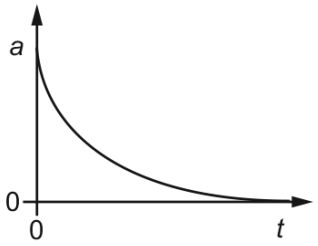
A



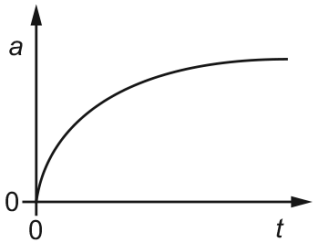
B



C



D

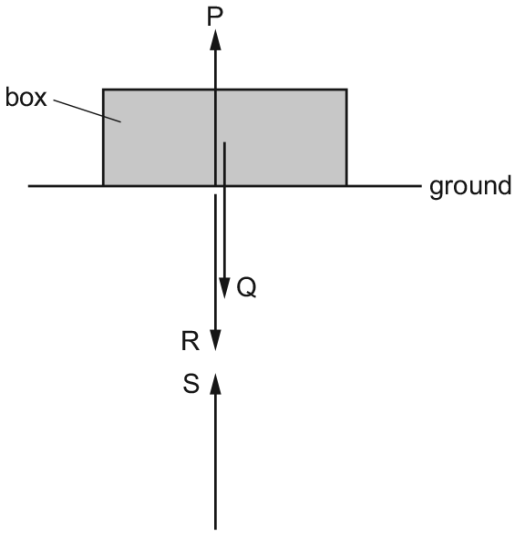


321. 9702_w16_qp_11 Q: 12

A box is shown resting on the ground. Newton's third law implies that four forces of equal magnitude are involved. These forces are labelled P, Q, R and S.

Forces P and Q act on the box. Forces R and S act on the Earth.

For clarity, the forces are shown slightly separated.



Which statement about the forces is correct?

A P is the equal and opposite force to Q and both are forces of contact.

B Q is the equal and opposite force to P and both are gravitational forces.

C R is the equal and opposite force to S and both are forces of contact.

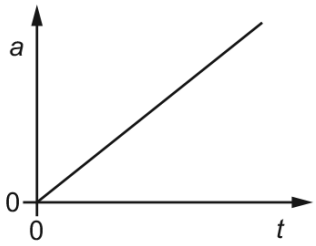
D S is the equal and opposite force to Q and both are gravitational forces.

322. 9702_w16_qp_13 Q: 10

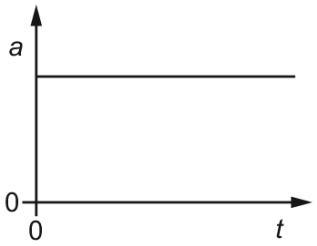
A beach-ball falls vertically from a high hotel window. Air resistance is **not** negligible.

Which graph shows the variation with time *t* of the acceleration *a* of the ball?

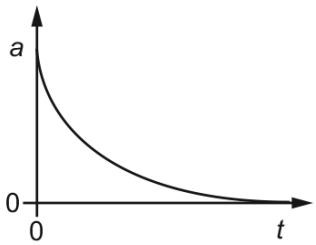
A



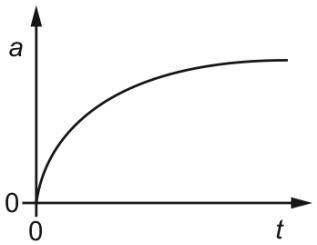
B



C



D

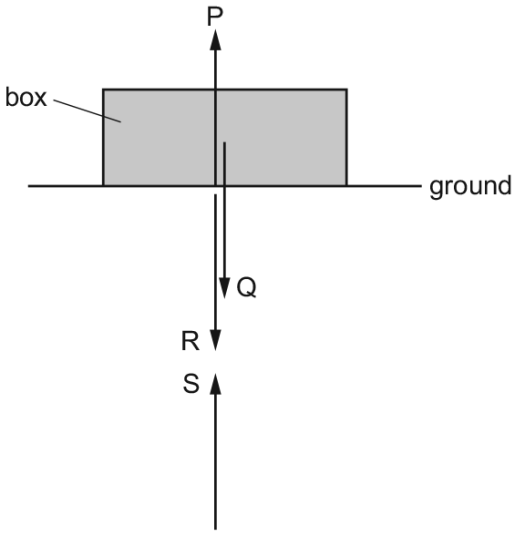


323. 9702_w16_qp_13 Q: 12

A box is shown resting on the ground. Newton's third law implies that four forces of equal magnitude are involved. These forces are labelled P, Q, R and S.

Forces P and Q act on the box. Forces R and S act on the Earth.

For clarity, the forces are shown slightly separated.



Which statement about the forces is correct?

A P is the equal and opposite force to Q and both are forces of contact.

B Q is the equal and opposite force to P and both are gravitational forces.

C R is the equal and opposite force to S and both are forces of contact.

D S is the equal and opposite force to Q and both are gravitational forces.

---

324. 9702_s15_qp_11 Q: 10

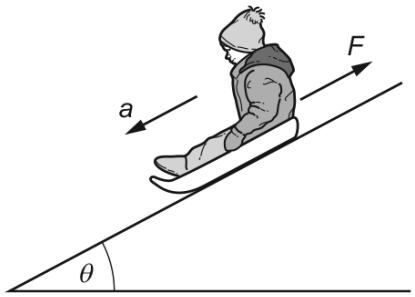
What is a reasonable estimate of the average gravitational force acting on a fully grown woman standing on the Earth?

A 60 N **B** 250 N **C** 350 N **D** 650 N

---

325. 9702_s15_qp_11 Q: 12

A child on a sledge slides down a hill with acceleration a. The hill makes an angle θ with the horizontal.



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 $m(g\cos\theta + a)$

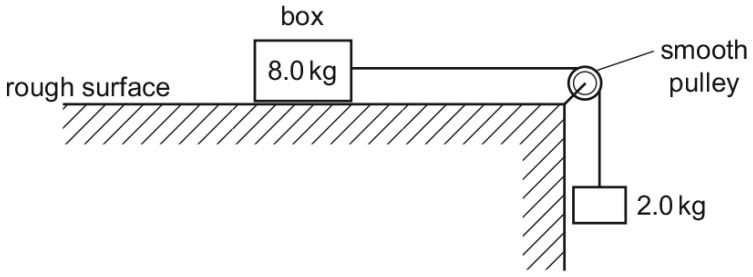
C $m(g\sin\theta - a)$

D $m(g\sin\theta + a)$

---

326. 9702_s15_qp_11 Q: 13

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.



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

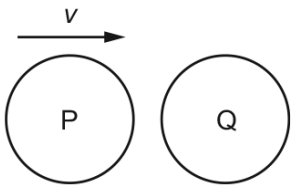
What is the acceleration of the box?

A $1.4\,\text{m s}^{-2}$ **B** $1.7\,\text{m s}^{-2}$ **C** $2.0\,\text{m s}^{-2}$ **D** $2.6\,\text{m s}^{-2}$

4.3 Linear momentum and its conservation

327. 9702_m20_qp_12 Q: 10

The diagram shows a particle P, travelling at speed v, about to collide with a stationary particle Q of the same mass. The collision is perfectly elastic.



Which statement describes the motion of P and of Q immediately after the collision?

A P and Q both travel in the same direction with speed $\frac{1}{2}v$.

B P comes to rest and Q acquires speed v.

C P rebounds with speed $\frac{1}{2}v$ and Q acquires speed $\frac{1}{2}v$.

D P rebounds with speed v and Q remains stationary.

---

328. 9702_s20_qp_11 Q: 10

A stationary toy gun fires a bullet.

Which statement about the bullet and the gun, immediately after firing, is **not** correct?

A The force exerted on the bullet by the gun has the same magnitude as the force exerted on the gun by the bullet.

B The force exerted on the bullet by the gun is in the opposite direction to the force exerted on the gun by the bullet.

C The gun and the bullet have the same magnitude of momentum.

D The kinetic energy of the gun must equal the kinetic energy of the bullet.

---

329. 9702_s20_qp_12 Q: 9

A mass m_1 travelling with speed u_1 collides with a mass m_2 travelling with speed u_2 in the same direction. After the collision, mass m_1 has speed v_1 and mass m_2 has speed v_2 in the same direction. The collision is perfectly elastic.



before the collision after the collision

Which equation is **not** correct?

A $m_1u_1^2 - m_1v_1^2 = m_2v_2^2 - m_2u_2^2$

B $v_2 + u_2 = v_1 + u_1$

C $m_1(u_1 - v_1) = m_2(v_2 - u_2)$

D $m_1(u_1 - v_1)^2 = m_2(u_2 - v_2)^2$

---

330. 9702_s20_qp_13 Q: 10

A ball of mass m, moving at a velocity v, collides with a stationary ball of mass $2m$.

The two balls stick together.

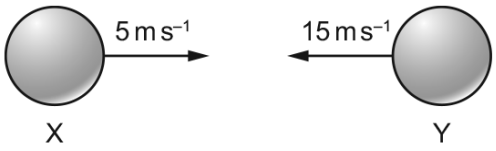
Which fraction of the initial kinetic energy is lost on impact?

A $\frac{1}{9}$ **B** $\frac{1}{3}$ **C** $\frac{2}{3}$ **D** $\frac{8}{9}$

---

331. 9702_m19_qp_12 Q: 8

Two balls X and Y are moving towards each other with speeds of $5\,m\,s^{-1}$ and $15\,m\,s^{-1}$ respectively.



They make a perfectly elastic head-on collision and ball Y moves to the right with a speed of $7\,m\,s^{-1}$.

What is the speed and direction of ball X after the collision?

A $3\,m\,s^{-1}$ to the left

B $13\,m\,s^{-1}$ to the left

C $3\,m\,s^{-1}$ to the right

D $13\,m\,s^{-1}$ to the right

---

332. 9702_s19_qp_11 Q: 11

A helium atom of mass m collides normally with a wall. The atom arrives at the wall with speed v and then rebounds along its original path. Assume that the collision is perfectly elastic.

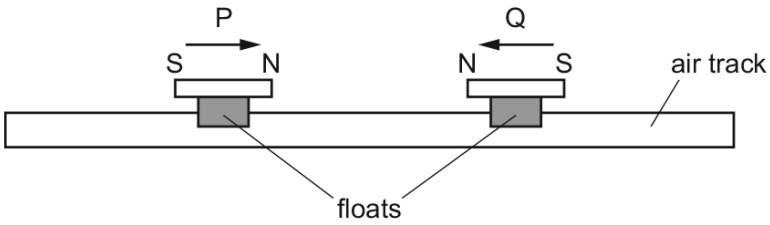
What is the change in the momentum of the atom during its collision?

A zero **B** $0.5mv$ **C** mv **D** $2mv$

---

333. 9702_s19_qp_12 Q: 11

Two bar magnets P and Q are mounted on floats which can slide without friction along an air track.



The two magnets slide towards each other along the air track and interact, without making contact.

The relative speed of approach of the magnets is equal to their relative speed of separation.

Which statement about P and Q must be correct?

A During the interaction between P and Q some of the total kinetic energy is lost.

B During the interaction between P and Q some of the total momentum is lost.

C The momentum of Q after the interaction is equal to the momentum of P before the interaction.

D The values of (kinetic energy of P + kinetic energy of Q) before and after the interaction are equal.

---

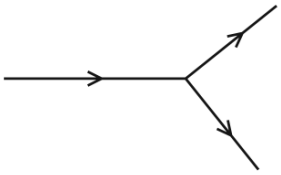
334. 9702_s19_qp_13 Q: 9

A nucleus collides with a stationary nucleus in a vacuum. The diagrams show the paths of the nuclei before and after the collision.

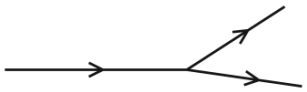
No other particles are involved in the collision.

Which diagram is **not** possible?

A



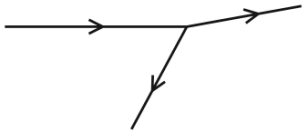
B



C



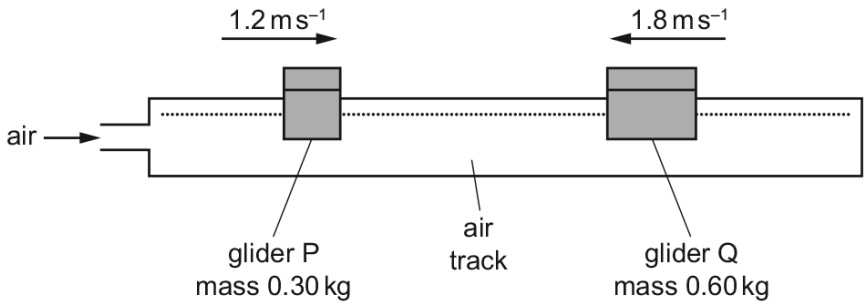
D



---

335. 9702_w19_qp_11 Q: 10

Two gliders are travelling towards each other on a horizontal air track. Glider P has mass 0.30 kg and is moving with a constant speed of 1.2 m s^{-1}. Glider Q has mass 0.60 kg and is moving with a constant speed of 1.8 m s^{-1}.



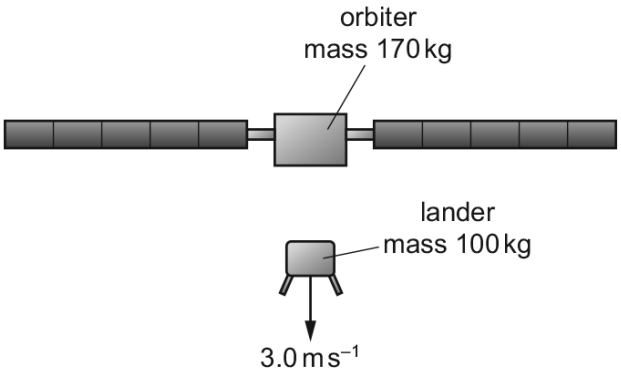
The gliders have a perfectly elastic collision.

What are the speeds of the two gliders after the collision?

	speed of P / m s^{-1}	speed of Q / m s^{-1}
A	1.2	0.6
B	2.0	1.4
C	2.8	0.2
D	3.6	0.6

336. 9702_w19_qp_12 Q: 9

The space probe Rosetta was designed to investigate a comet. The probe consisted of an orbiter and a lander. The orbiter had a mass of 170 kg and the lander had a mass of 100 kg. When the two parts separated, the lander was pushed towards the surface of the comet so that its change in velocity towards the comet was $3.0\,m\,s^{-1}$.



Assume that the orbiter and lander were an isolated system.

The orbiter moved away from the comet during the separation.

What was the change in the speed of the orbiter?

A $1.8\,m\,s^{-1}$ **B** $2.3\,m\,s^{-1}$ **C** $3.0\,m\,s^{-1}$ **D** $5.1\,m\,s^{-1}$

---

337. 9702_w19_qp_13 Q: 9

Two objects X and Y in an isolated system undergo a perfectly elastic collision. The velocities of the objects before and after the collision are shown.



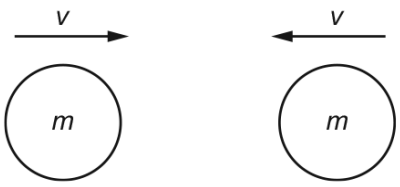
What is the speed v of Y after the collision?

A $2.0\,m\,s^{-1}$ **B** $18\,m\,s^{-1}$ **C** $22\,m\,s^{-1}$ **D** $24\,m\,s^{-1}$

---

338. 9702_s18_qp_11 Q: 9

Two similar spheres, each of mass m and travelling with speed v, are moving towards each other.



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 $2mv$.

---

339. 9702_s18_qp_12 Q: 9

An elastic collision occurs between two bodies X and Y. The mass of body X is m and the mass of body Y is $4m$. Body X travels at speed v before the collision and speed $\frac{3v}{5}$ in the opposite direction after the collision. Body Y is stationary before the collision.



What is the kinetic energy of body Y after the collision?

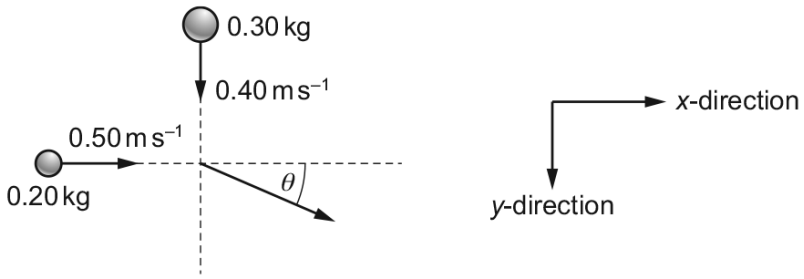
A $\frac{8}{10}mv^2$ **B** $\frac{34}{50}mv^2$ **C** $\frac{16}{50}mv^2$ **D** $\frac{1}{5}mv^2$

---

340. 9702_s18_qp_13 Q: 9

A ball of mass 0.20 kg, travelling in the *x*-direction at a speed of 0.50 m s^{-1}, collides with a ball of mass 0.30 kg travelling in the *y*-direction at a speed of 0.40 m s^{-1}.

The two balls stick together after the collision, travelling at an angle θ to the *x*-direction.



What is the value of θ?

A 39° **B** 40° **C** 50° **D** 51°

---

341. 9702_w18_qp_11 Q: 9

What is a statement of the principle of conservation of momentum?

A A force is equal to the rate of change of momentum of the body upon which it acts.

B In a perfectly elastic collision, the relative momentum of the bodies before impact is equal to their relative momentum after impact.

C The momentum of a body is the product of the mass of the body and its velocity.

D The total momentum of a system of interacting bodies remains constant, providing no resultant external force acts on the system.

---

342. 9702_w18_qp_12 Q: 9

Two bodies travelling along the same straight line collide in a perfectly elastic collision.

Which statement **must** be correct?

A The initial speed of one body will be the same as the final speed of the other body.

B The relative speed of approach between the two bodies equals their relative speed of separation.

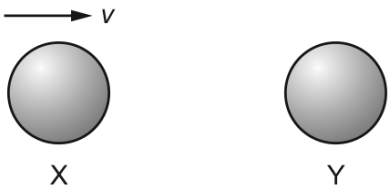
C The total momentum is conserved but the total kinetic energy will be reduced.

D One of the bodies will be stationary at one instant.

---

343. 9702_w18_qp_12 Q: 10

The diagram shows two identical spheres X and Y.



Initially, X moves with speed v directly towards Y. Y is stationary. The spheres collide elastically.

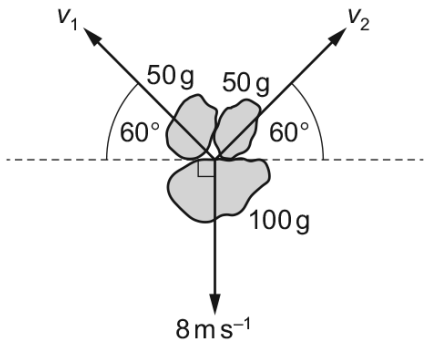
What happens?

	X	Y
A	moves with speed $\frac{1}{2}v$ to the right	moves with speed $\frac{1}{2}v$ to the right
B	moves with speed v to the left	remains stationary
C	moves with speed $\frac{1}{2}v$ to the left	moves with speed $\frac{1}{2}v$ to the right
D	stops	moves with speed v to the right

---

344. 9702_m17_qp_12 Q: 10

A stationary firework explodes into three pieces. The masses and the velocities of the three pieces immediately after the explosion are shown.



What are speed v_1 and speed v_2?

	v_1 / m s^{-1}	v_2 / m s^{-1}
A	4.0	4.0
B	9.2	9.2
C	14	14
D	16	16

---

345. 9702_s17_qp_12 Q: 14

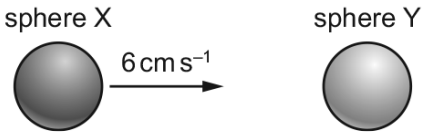
Which quantities are conserved in an inelastic collision?

	kinetic energy	total energy	linear momentum
A	conserved	not conserved	conserved
B	conserved	not conserved	not conserved
C	not conserved	conserved	conserved
D	not conserved	conserved	not conserved

---

346. 9702_w17_qp_11 Q: 11

Two solid spheres form an isolated system. Sphere X moves with speed $6\,cm\,s^{-1}$ in a straight line directly towards a stationary sphere Y, as shown.



The spheres have a perfectly elastic collision. After the collision, sphere X moves with speed $2\,cm\,s^{-1}$ in the same direction as before the collision.

What is the speed of sphere Y?

A $2\,cm\,s^{-1}$ **B** $4\,cm\,s^{-1}$ **C** $6\,cm\,s^{-1}$ **D** $8\,cm\,s^{-1}$

---

347. 9702_w17_qp_12 Q: 9

A slow vehicle and a fast vehicle travel towards each other in a straight line and then collide.

Which outcome is **never** possible, regardless of the masses of the vehicles?

A Both vehicles stop.

B Only one vehicle stops.

C The fast vehicle's speed increases.

D The slow vehicle's speed increases.

---

348. 9702_w17_qp_13 Q: 10

Two railway trucks of masses m and $3m$ move towards each other in opposite directions with speeds $2v$ and v respectively. These trucks collide and stick together.

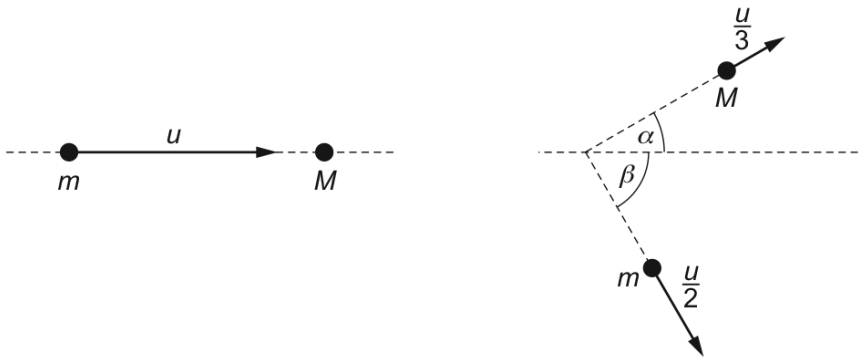
What is the speed of the trucks after the collision?

A $\frac{v}{4}$ **B** $\frac{v}{2}$ **C** v **D** $\frac{5v}{4}$

---

349. 9702_m16_qp_12 Q: 10

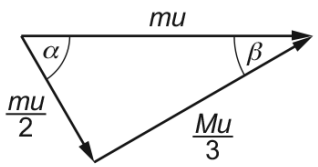
A particle of mass m, travelling with speed u, collides with a stationary particle of mass M. The velocities of the two particles before and after the collision are shown.



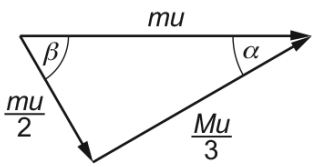
before collision after collision

Which vector diagram correctly shows the momenta before and after the collision?

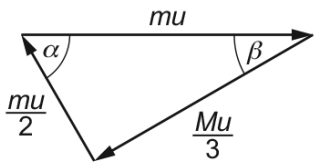
A



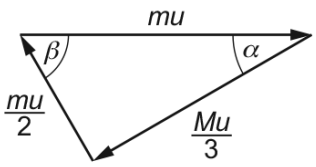
B



C



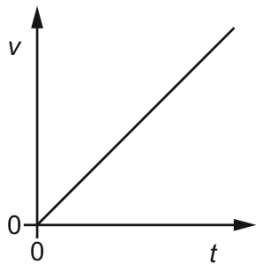
D



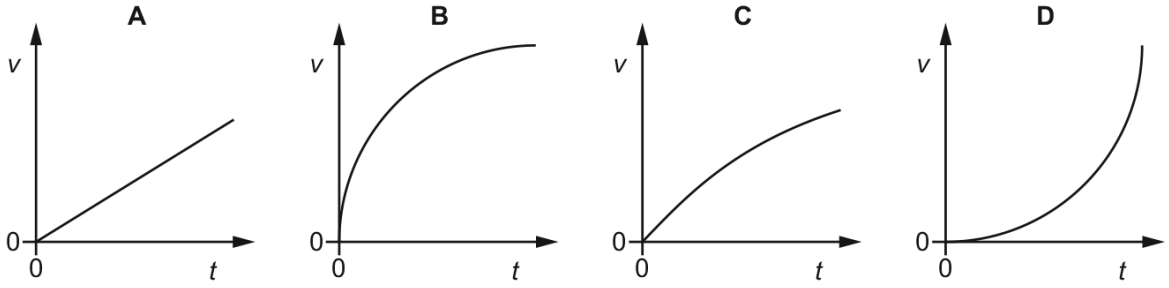
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350. 9702_m16_qp_12 Q: 11

An object falls freely from rest in a vacuum. The graph shows the variation with time t of the velocity v of the object.



Which graph, using the same scales, represents the object falling in air?



---

351. 9702_s16_qp_11 Q: 9

Which statement about a perfectly elastic collision between two bodies in an isolated system is correct?

A Both total kinetic energy and total momentum are conserved.

B Total kinetic energy is conserved, but total momentum is not conserved.

C Total momentum is conserved, but total kinetic energy is not conserved.

D Neither total kinetic energy nor total momentum is conserved.

---

352. 9702_s16_qp_11 Q: 10

Two spheres approach each other along the same straight line. Their speeds are u_1 and u_2 before they collide. After the collision, the spheres separate with speeds v_1 and v_2 in the directions shown below.



The collision is perfectly elastic. Which equation must be correct?

A $u_1 - u_2 = v_2 + v_1$

B $u_1 - u_2 = v_2 - v_1$

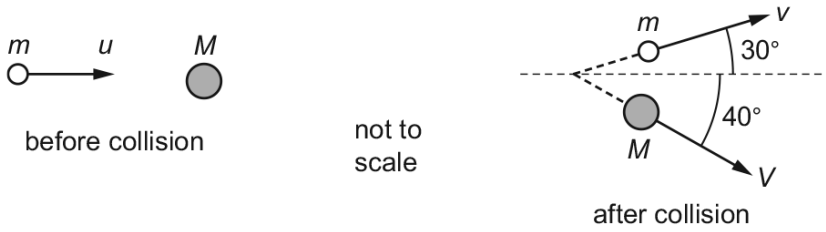
C $u_1 + u_2 = v_2 + v_1$

D $u_1 + u_2 = v_2 - v_1$

---

353. 9702_s16_qp_12 Q: 11

A ball of mass m travelling at velocity u collides with a stationary ball of mass M. After collision the two balls travel at velocities v and V respectively, in the directions shown.



A student writes three equations relating to the collision.

Which row in the table indicates the correct and incorrect equations?

	$mu = MV + mv$	$mv \sin 30° = MV \sin 40°$	$mu = mv \cos 30° + MV \cos 40°$
A	correct	correct	correct
B	incorrect	correct	incorrect
C	correct	incorrect	incorrect
D	incorrect	correct	correct

---

354. 9702_s16_qp_13 Q: 10

Two equal masses travel towards each other on a frictionless track at speeds of $60\,\text{cm}\,\text{s}^{-1}$ and $30\,\text{cm}\,\text{s}^{-1}$. They stick together on impact.



What is the speed of the masses after impact?

A $15\,\text{cm}\,\text{s}^{-1}$ **B** $20\,\text{cm}\,\text{s}^{-1}$ **C** $30\,\text{cm}\,\text{s}^{-1}$ **D** $45\,\text{cm}\,\text{s}^{-1}$

---

355. 9702_w16_qp_11 Q: 13

Two spheres travel along the same line with velocities u_1 and u_2. They collide and after collision their velocities are v_1 and v_2.



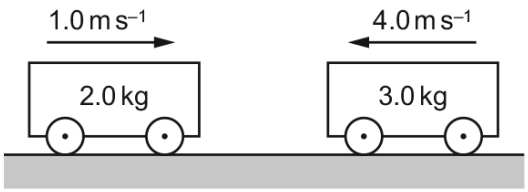
Which collision is **not** elastic?

	$u_1/\text{m}\,\text{s}^{-1}$	$u_2/\text{m}\,\text{s}^{-1}$	$v_1/\text{m}\,\text{s}^{-1}$	$v_2/\text{m}\,\text{s}^{-1}$
A	2	–5	–5	–2
B	3	–3	0	6
C	3	–2	1	6
D	5	2	3	6

---

356. 9702_w16_qp_12 Q: 11

Two frictionless trolleys are moving towards each other along the same horizontal straight line. Their masses and velocities are shown.



The trolleys collide and stick together.

What is the velocity of the trolleys after the collision?

A 2.0 m s^{-1} to the left

B 2.0 m s^{-1} to the right

C 2.8 m s^{-1} to the left

D 2.8 m s^{-1} to the right

---

357. 9702_w16_qp_13 Q: 13

Two spheres travel along the same line with velocities u_1 and u_2. They collide and after collision their velocities are v_1 and v_2.



Which collision is **not** elastic?

	u_1 / m s^{-1}	u_2 / m s^{-1}	v_1 / m s^{-1}	v_2 / m s^{-1}
A	2	–5	–5	–2
B	3	–3	0	6
C	3	–2	1	6
D	5	2	3	6

---

358. 9702_s15_qp_11 Q: 11

A molecule of mass m travelling at speed v hits a wall in a direction perpendicular to the wall. The collision is elastic.

What are the changes in the momentum and in the kinetic energy of the molecule caused by the collision?

	change in momentum	change in kinetic energy
A	0	0
B	0	mv^2
C	$2mv$	0
D	mv^2	0

---

359. 9702_s15_qp_12 Q: 11

Trolley X, moving along a horizontal frictionless track, collides with a stationary trolley Y. The two trolleys become attached and move off together.

Which statement about this interaction is correct?

A Some of the kinetic energy of trolley X is changed to momentum in the collision.

B Some of the momentum of trolley X is changed to kinetic energy in the collision.

C Trolley X loses some of its momentum as heat in the collision.

D Trolley X shares its momentum with trolley Y but some of its kinetic energy is lost.

---

360. 9702_s15_qp_13 Q: 10

Which of the following is a statement of the principle of conservation of momentum?

A Momentum is the product of mass and velocity.

B In an elastic collision, momentum is constant.

C The momentum of an isolated system is constant.

D The force acting on a body is proportional to its rate of change of momentum.

---

361. 9702_s15_qp_13 Q: 11

A moving object strikes a stationary object. The collision is inelastic. The objects move off together.

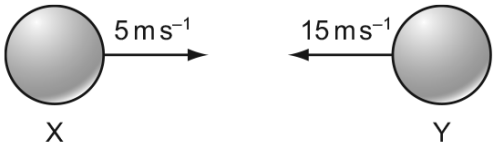
Which row shows the possible values of total momentum and total kinetic energy for the system before and after the collision?

	total momentum before collision / kg m s^{-1}	total momentum after collision / kg m s^{-1}	total kinetic energy before collision / J	total kinetic energy after collision / J
A	6	2	90	30
B	6	6	30	90
C	6	6	90	30
D	6	6	90	90

---

362. 9702_s15_qp_13 Q: 12

Two balls X and Y are moving towards each other with speeds of 5 m s^{-1} and 15 m s^{-1} respectively.



They make a perfectly elastic head-on collision and ball Y moves to the right with a speed of 7 m s^{-1}.

What is the speed and direction of ball X after the collision?

A 3 m s^{-1} to the left

B 13 m s^{-1} to the left

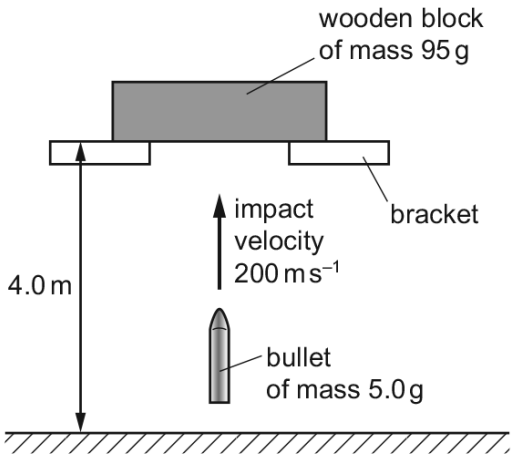
C 3 m s^{-1} to the right

D 13 m s^{-1} to the right

---

363. 9702_s15_qp_13 Q: 13

A wooden block is freely supported on brackets at a height of 4.0 m above the ground, as shown.



A bullet of mass 5.0 g is shot vertically upwards into the wooden block of mass 95 g. It embeds itself in the block. The impact causes the block to rise above its supporting brackets.

The bullet hits the block with a velocity of 200 m s^{-1}. How far above the ground will the block be at the maximum height of its path?

A 5.1 m **B** 5.6 m **C** 9.1 m **D** 9.6 m

Chapter 4

Dynamics

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4.1 Momentum and Newton's laws of motion

33. 9702_w20_qp_21 Q: 3

(a) Define *force*.

.....

..... [1]

(b) A ball falls vertically downwards towards a horizontal floor and then rebounds along its original path, as illustrated in Fig. 3.1.

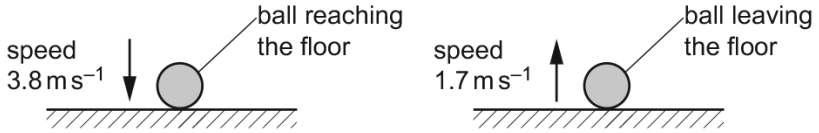


Fig. 3.1

The ball reaches the floor with speed $3.8\,m\,s^{-1}$. The ball is then in contact with the floor for a time of 0.081 s before leaving it with speed $1.7\,m\,s^{-1}$. The mass of the ball is 0.062 kg.

(i) Calculate the loss of kinetic energy of the ball during the collision.

loss of kinetic energy = ... J [2]

(ii) Determine the magnitude of the change in momentum of the ball during the collision.

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

(iii) Show that the magnitude of the average resultant force acting on the ball during the collision is 4.2 N.

[1]

(iv) Use the information in **(iii)** to calculate the magnitude of:

1. the average force of the floor on the ball during the collision

average force = ... N

2. the average force of the ball on the floor during the collision.

average force = ... N
[2]

[Total: 8]

---

34. 9702_s19_qp_21 Q: 2

A block X slides along a horizontal frictionless surface towards a stationary block Y, as illustrated in Fig. 2.1.

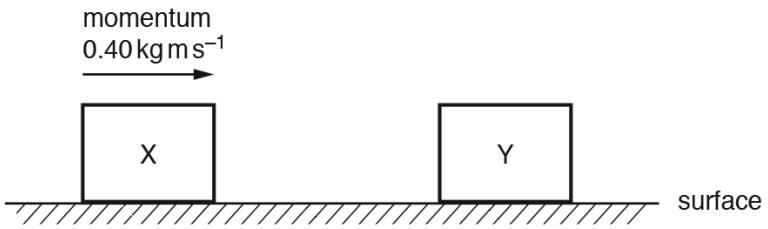


Fig. 2.1

There are no resistive forces acting on block X as it moves towards block Y. At time $t = 0$, block X has momentum $0.40\,\text{kg m s}^{-1}$. A short time later, the blocks collide and then separate.

The variation with time t of the momentum of block Y is shown in Fig. 2.2.

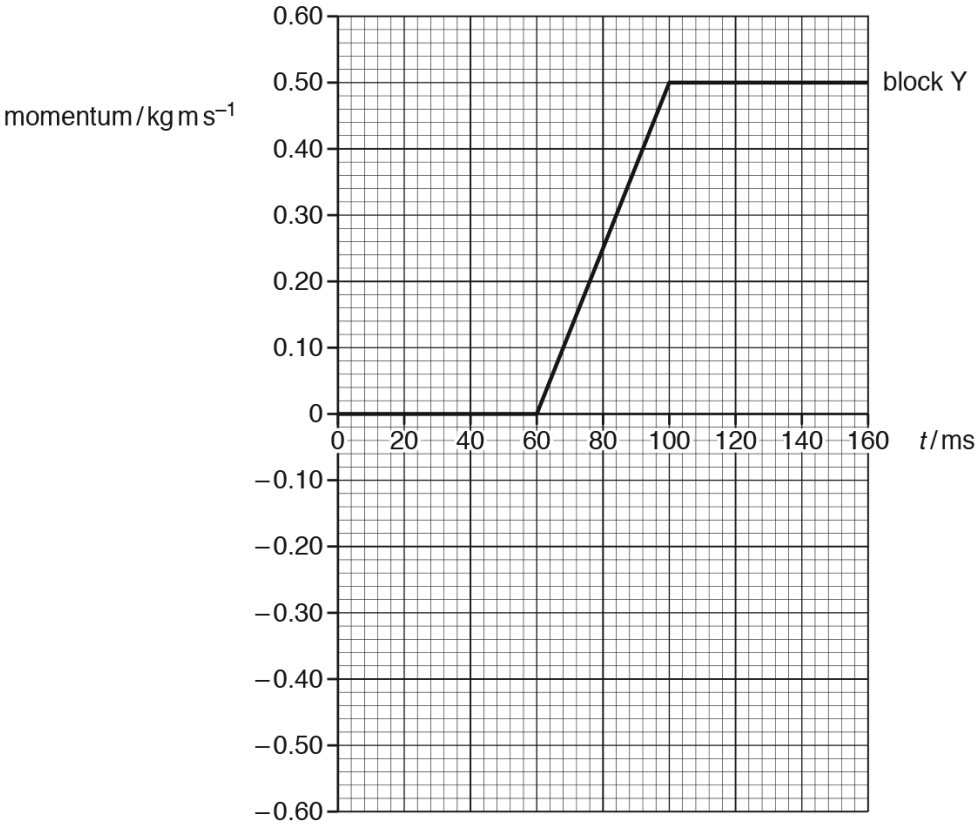


Fig. 2.2

(a) Define *linear momentum*.

.....[1]

(b) Use Fig. 2.2 to:

(i) determine the time interval over which the blocks are in contact with each other

time interval = ... ms [1]

(ii) describe, without calculation, the magnitude of the acceleration of block Y from:

1. time $t = 80\,\text{ms}$ to $t = 100\,\text{ms}$

.....

2. time $t = 100\,\text{ms}$ to $t = 120\,\text{ms}$.

.....
[2]

(c) Use Fig. 2.2 to determine the magnitude of the force exerted by block X on block Y.

force = ... N [2]

(d) On Fig. 2.2, sketch the variation of the momentum of block X with time t from $t = 0$ to $t = 160\,\text{ms}$. [3]

[Total: 9]

35. 9702_w17_qp_21 Q: 1

(a) The drag force F_D acting on a sphere moving through a fluid is given by the expression

$$F_D = K\rho v^2$$

where K is a constant,
ρ is the density of the fluid
and v is the speed of the sphere.

Determine the SI base units of K.

base units .....[3]

(b) A ball of weight 1.5 N falls vertically from rest in air. The drag force F_D acting on the ball is given by the expression in **(a)**. The ball reaches a constant (terminal) speed of 33 m s^{-1}.

Assume that the upthrust acting on the ball is negligible and that the density of the air is uniform.

For the instant when the ball is travelling at a speed of 25 m s^{-1}, determine

(i) the drag force F_D on the ball,

F_D = ... N [2]

(ii) the acceleration of the ball.

acceleration = ... m s^{-2} [2]

(c) Describe the acceleration of the ball in **(b)** as its speed changes from zero to 33 m s^{-1}.

.....

.....

.....

.....[3]

[Total: 10]

4.2 Linear momentum and its conservation

36. 9702_s20_qp_22 Q: 2

(a) Fig. 2.1 shows the velocity–time graph for an object moving in a straight line.

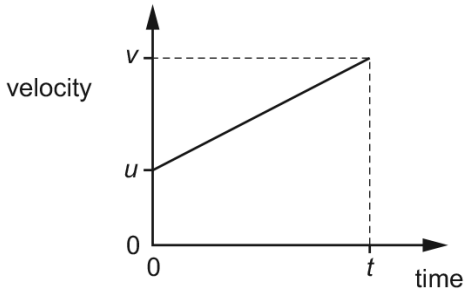


Fig. 2.1

(i) Determine an expression, in terms of u, v and t, for the area under the graph.

area = ... [1]

(ii) State the name of the quantity represented by the area under the graph.

..... [1]

(b) A ball is kicked with a velocity of $15\,m\,s^{-1}$ at an angle of 60° to horizontal ground. The ball then strikes a vertical wall at the instant when the path of the ball becomes horizontal, as shown in Fig. 2.2.

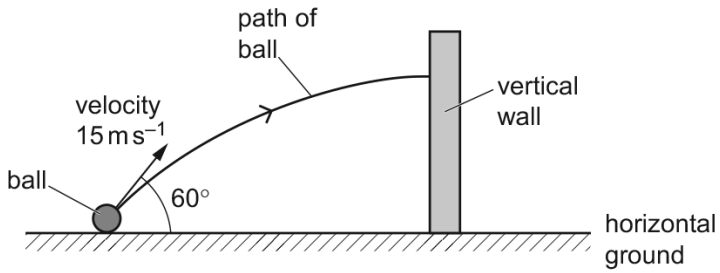


Fig. 2.2 (not to scale)

Assume that air resistance is negligible.

(i) By considering the vertical motion of the ball, calculate the time it takes to reach the wall.

time = ... s [3]

(ii) Explain why the horizontal component of the velocity of the ball remains constant as it moves to the wall.

.....

..... [1]

(iii) Show that the ball strikes the wall with a horizontal velocity of $7.5\,m\,s^{-1}$.

[1]

(c) The mass of the ball in **(b)** is 0.40 kg. It is in contact with the wall for a time of 0.12 s and rebounds horizontally with a speed of $4.3\,m\,s^{-1}$.

(i) Use the information from **(b)(iii)** to calculate the change in momentum of the ball due to the collision.

change in momentum = ... $kg\,m\,s^{-1}$ [2]

(ii) Calculate the magnitude of the average force exerted on the ball by the wall.

average force = ... N [1]

[Total: 10]

37. 9702_w20_qp_23 Q: 3

A ball is fired horizontally with a speed of $41.0\,m\,s^{-1}$ from a stationary cannon at the top of a hill. The ball lands on horizontal ground that is a vertical distance of 57 m below the cannon, as shown in Fig. 3.1.

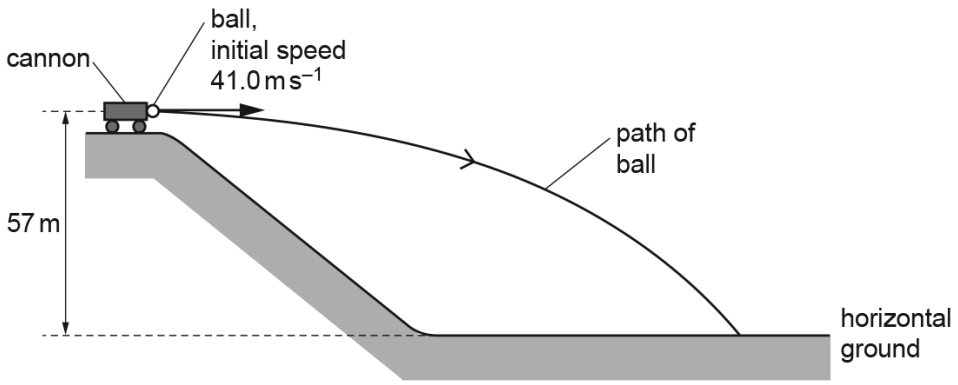


Fig. 3.1 (not to scale)

Assume air resistance is negligible.

(a) Show that the time taken for the ball to reach the ground, after being fired, is 3.4 s.

[2]

(b) Calculate the horizontal distance of the ball from the cannon at the point where the ball lands on the ground.

horizontal distance = ... m [1]

(c) Determine the magnitude of the displacement of the ball from the cannon at the point where the ball lands on the ground.

displacement = ... m [2]

(d) The ball leaves the cannon at time $t = 0$.

On Fig. 3.2, sketch a graph to show the variation of the magnitude v of the vertical component of the velocity of the ball with time t from $t = 0$ to $t = 3.4\,s$.
Numerical values are not required.

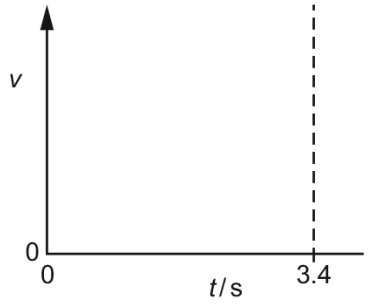


Fig. 3.2

[1]

(e) The cannon recoils horizontally with a speed of $0.340\,m\,s^{-1}$ when it fires the ball. The total mass of the ball and the cannon is 1480 kg. Assume that no external horizontal forces act on the ball-cannon system.

Determine, to three significant figures, the mass of the ball.

mass = ... kg [2]

(f) The cannon now fires a ball of smaller mass. Assume that air resistance is still negligible.

State and explain the change, if any, to the graph in Fig. 3.2 due to the decreased mass of the ball.

.....

.....

..... [2]

[Total: 10]

38. 9702_w18_qp_21 Q: 2

A wooden block moves along a horizontal frictionless surface, as shown in Fig. 2.1.

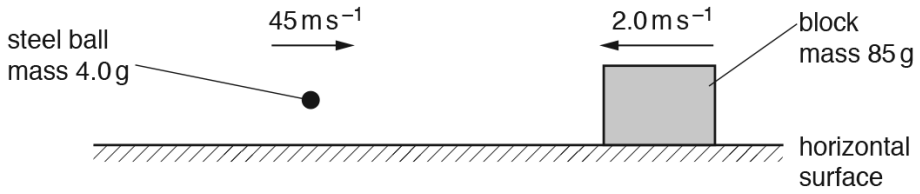


Fig. 2.1

The block has mass 85 g and moves to the left with a velocity of 2.0 m s^{-1}. A steel ball of mass 4.0 g is fired to the right. The steel ball, moving horizontally with a speed of 45 m s^{-1}, collides with the block and remains embedded in it. After the collision the block and steel ball both have speed v.

(a) Calculate v.

v = ... m s^{-1} [2]

(b) **(i)** For the block and ball, state

1. the relative speed of approach before collision,

relative speed of approach = ... m s^{-1}

2. the relative speed of separation after collision.

relative speed of separation = ... m s^{-1} [1]

(ii) Use your answers in **(i)** to state and explain whether the collision is elastic or inelastic.

.....

..... [1]

(c) Use Newton's third law to explain the relationship between the rate of change of momentum of the ball and the rate of change of momentum of the block during the collision.

.....

.....

.....

..... [2]

[Total: 6]

39. 9702_s17_qp_23 Q: 2

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

.....

.....[1]

(b) A constant resultant force F acts on an object A. The variation with time t of the velocity v for the motion of A is shown in Fig. 2.1.

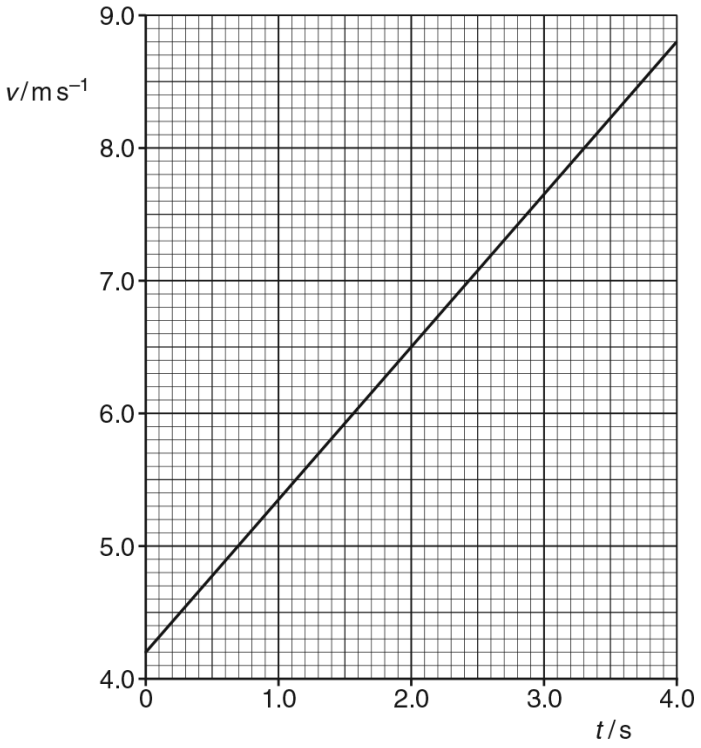


Fig. 2.1

The mass of A is 840 g.

Calculate, for the time $t = 0$ to $t = 4.0$ s,

(i) the change in momentum of A,

change in momentum = ... kg m s^{-1} [2]

(ii) the force F.

F = ... N [1]

(c) The force F is removed at $t = 4.0\,s$. Object A continues at constant velocity before colliding with an object B, as illustrated in Fig. 2.2.



Fig. 2.2

Object B is initially at rest. The mass of B is 730 g.
The objects A and B join together and have a velocity of $4.7\,m\,s^{-1}$.

(i) By calculation, show that the changes in momentum of A and of B during the collision are equal and opposite.

[2]

(ii) Explain how the answers obtained in **(i)** support Newton's third law.

.....

.....

.....

.....[2]

(iii) By reference to the speeds of A and B, explain whether the collision is elastic.

.....

.....[1]

[Total: 9]

40. 9702_w17_qp_23 Q: 3

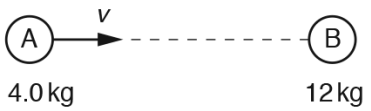
(a) State the principle of conservation of momentum.

.....

.....

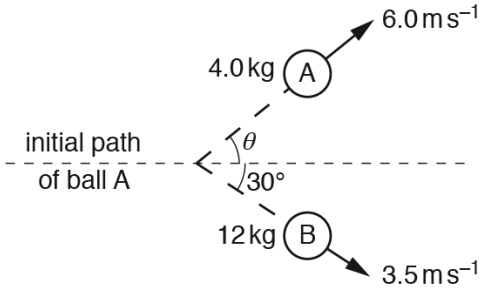
.....[2]

(b) Ball A moves with speed v along a horizontal frictionless surface towards a stationary ball B, as shown in Fig. 3.1.



before collision

Fig. 3.1



after collision

Fig. 3.2 (not to scale)

Ball A has mass 4.0 kg and ball B has mass 12 kg.
The balls collide and then move apart as shown in Fig. 3.2.
Ball A has velocity 6.0 m s^{-1} at an angle of θ to the direction of its initial path.
Ball B has velocity 3.5 m s^{-1} at an angle of 30° to the direction of the initial path of ball A.

(i) By considering the components of momentum at right-angles to the direction of the initial path of ball A, calculate θ.

θ = ... ° [3]

(ii) Use your answer in **(i)** to show that the initial speed v of ball A is $12\,\text{m}\,\text{s}^{-1}$.
Explain your working.

[2]

(iii) By calculation of kinetic energies, state and explain whether the collision is elastic or inelastic.

.....

.....[3]

[Total: 10]

---

41. 9702_s16_qp_23 Q: 5

(a) State the law of conservation of momentum.

.....

.....

..... [2]

(b) Two particles A and B collide elastically, as illustrated in Fig. 5.1.

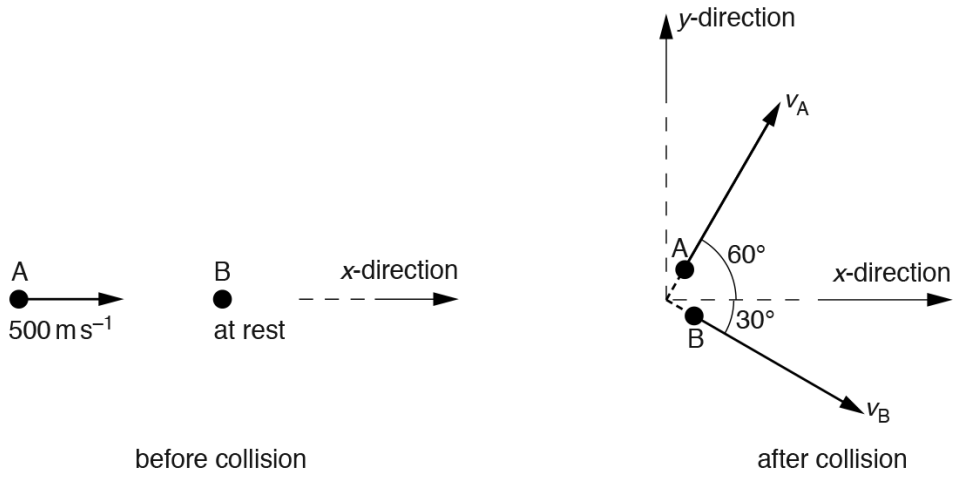


Fig. 5.1

The initial velocity of A is 500 m s^{-1} in the *x*-direction and B is at rest.

The velocity of A after the collision is v_A at 60° to the *x*-direction. The velocity of B after the collision is v_B at 30° to the *x*-direction.

The mass *m* of each particle is 1.67×10^{-27} kg.

(i) Explain what is meant by the particles colliding *elastically*.

..... [1]

(ii) Calculate the total initial momentum of A and B.

momentum = ...N s [1]

(iii) State an expression in terms of m, v_A and v_B for the total momentum of A and B after the collision

1. in the x-direction,

.....

2. in the y-direction.

.....
[2]

(iv) Calculate the magnitudes of the velocities v_A and v_B after the collision.

v_A = ... $m\,s^{-1}$

v_B = ... $m\,s^{-1}$
[3]

[Total: 9]

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42. 9702_s15_qp_21 Q: 3

Two balls X and Y are supported by long strings, as shown in Fig. 3.1.

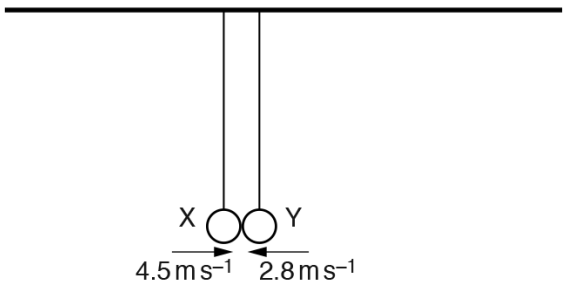


Fig. 3.1

The balls are each pulled back and pushed towards each other. When the balls collide at the position shown in Fig. 3.1, the strings are vertical. The balls rebound in opposite directions.

Fig. 3.2 shows data for X and Y during this collision.

ball	mass	velocity just before collision / m s^{-1}	velocity just after collision / m s^{-1}
X	50 g	+4.5	–1.8
Y	*M*	–2.8	+1.4

Fig. 3.2

The positive direction is horizontal and to the right.

(a) Use the conservation of linear momentum to determine the mass *M* of Y.

M = ... g [3]

(b) State and explain whether the collision is elastic.

.....

.....

.....[1]

(c) Use Newton's second and third laws to explain why the magnitude of the change in momentum of each ball is the same.

.....

.....

.....

.....

.....[3]

---

1 Two similar spheres, each of mass m and travelling with speed v, are moving towards each other.

9702/1/M/J/02/Q9



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 $2mv$.

2 A body, initially at rest, explodes into two masses M_1 and M_2 that move apart with speeds v_1 and v_2 respectively.

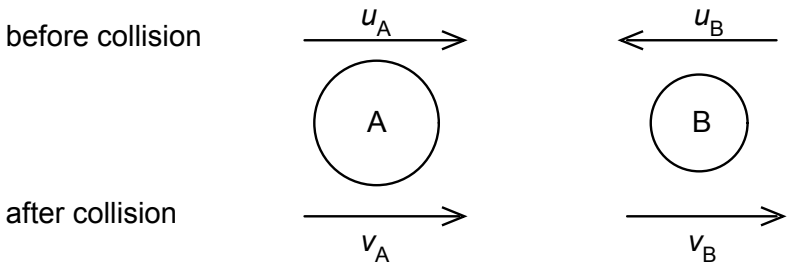
9702/1/M/J/02/Q11

What is the ratio $\frac{v_1}{v_2}$?

A $\frac{M_1}{M_2}$ **B** $\frac{M_2}{M_1}$ **C** $\left(\frac{M_1}{M_2}\right)^{\frac{1}{2}}$ **D** $\left(\frac{M_2}{M_1}\right)^{\frac{1}{2}}$

3 Two spheres A and B approach each other along the same straight line with speeds u_A and u_B. The spheres collide and move off with speeds v_A and v_B, both in the same direction as the initial direction of sphere A, as shown below.

9702/1/O/N/02/Q11



Which equation applies to an elastic collision?

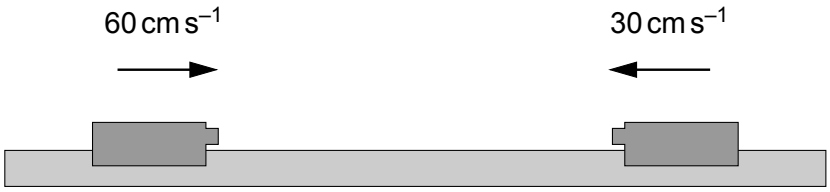
A $u_A + u_B = v_B - v_A$

B $u_A - u_B = v_B - v_A$

C $u_A - u_B = v_B + v_A$

D $u_A + u_B = v_B + v_A$

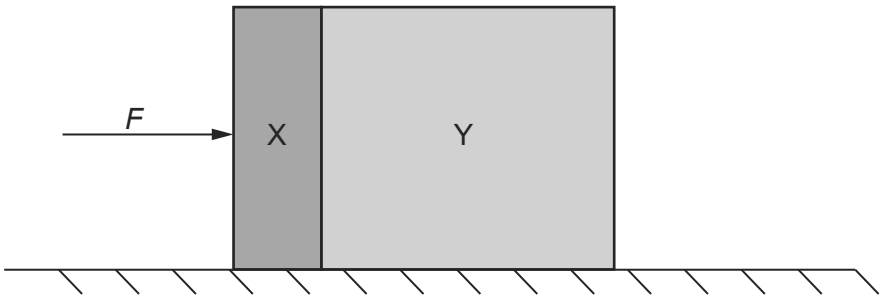
4 Two equal masses travel towards each other on a frictionless air track at speeds of 60 cm s^{-1} and 30 cm s^{-1}. They stick together on impact. 9702/1/O/N/02/Q12



What is the speed of the masses after impact?

A 15 cm s^{-1} **B** 20 cm s^{-1} **C** 30 cm s^{-1} **D** 45 cm s^{-1}

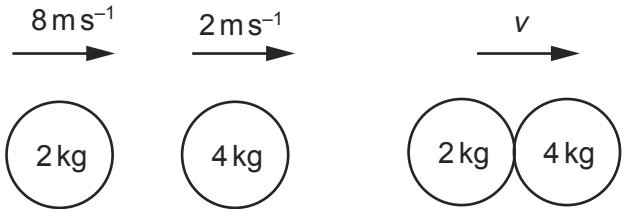
5 Two blocks X and Y, of masses m and $3m$ respectively, are accelerated along a smooth horizontal surface by a force F applied to block X as shown. 9702/01/M/J/03/Q10



What is the magnitude of the force exerted by block X on block Y during this acceleration?

A $\frac{F}{4}$ **B** $\frac{F}{3}$ **C** $\frac{F}{2}$ **D** $\frac{3F}{4}$

6 A ball of mass 2 kg travelling at 8 m s^{-1} strikes a ball of mass 4 kg travelling at 2 m s^{-1}. Both balls are moving along the same straight line as shown. 9702/01/M/J/03/Q12



After collision, both balls move at the same velocity v.

What is the magnitude of the velocity v?

A 4 m s^{-1} **B** 5 m s^{-1} **C** 6 m s^{-1} **D** 8 m s^{-1}

7 A mass accelerates uniformly when the resultant force acting on it 9702/01/O/N/03/Q10

A is zero.

B is constant but not zero.

C increases uniformly with respect to time.

D is proportional to the displacement from a fixed point.

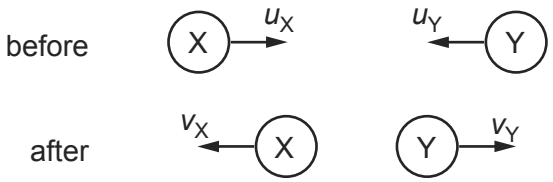
8 A molecule of mass m travelling horizontally with velocity u hits a vertical wall at right angles to the wall. It then rebounds horizontally with the same speed. 9702/01/O/N/03/Q11

What is its change in momentum?

A zero **B** mu **C** $-mu$ **D** $-2mu$

9 Two balls X and Y approach each other along the same straight line and collide elastically.

Their speeds are u_X and u_Y respectively. After the collision they move apart with speeds v_X and v_Y respectively. Their directions are shown on the diagram. 9702/01/O/N/03/Q12



Which of the following equations is correct?

A $u_X + u_Y = v_X + v_Y$

B $u_X + u_Y = v_X - v_Y$

C $u_X - u_Y = v_X + v_Y$

D $u_X - u_Y = v_X - v_Y$

10 Two equal masses travel towards each other on a frictionless air track at speeds of $60\,\text{cm}\,\text{s}^{-1}$ and $40\,\text{cm}\,\text{s}^{-1}$. They stick together on impact. 9702/01/M/J/05/Q11



What is the speed of the masses after impact?

A $10\,\text{cm}\,\text{s}^{-1}$ **B** $20\,\text{cm}\,\text{s}^{-1}$ **C** $40\,\text{cm}\,\text{s}^{-1}$ **D** $50\,\text{cm}\,\text{s}^{-1}$

11 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.

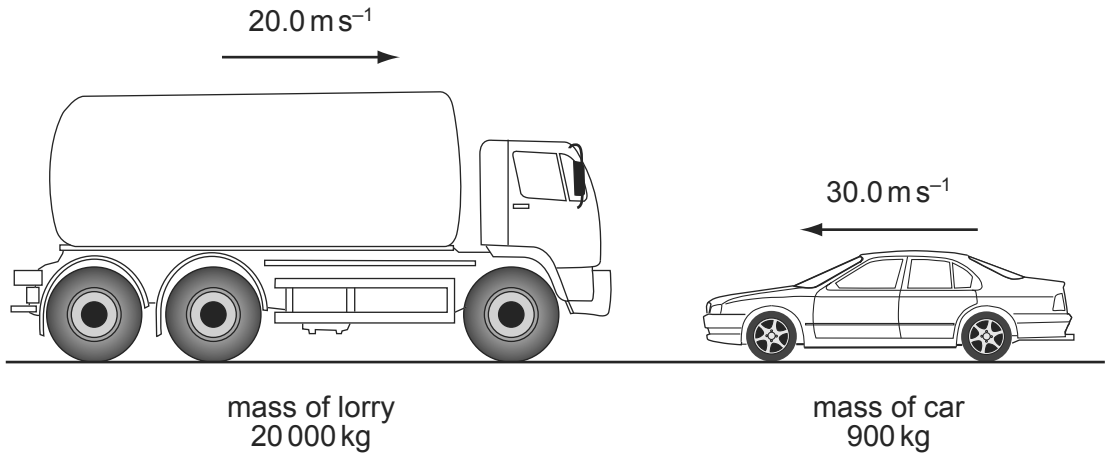
B The force that the ball exerts on the ground is always equal in magnitude and opposite in direction to the force the ground exerts on the ball.

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.

12 The diagram shows a situation just before a head-on collision. A lorry of mass 20 000 kg is travelling at 20.0 m s^{-1} towards a car of mass 900 kg travelling at 30.0 m s^{-1} towards the lorry.

9702/01/M/J/04/Q11



What is the magnitude of the total momentum?

A 373 kN s **B** 427 kN s **C** 3600 kN s **D** 4410 kN s

13 Which of the following is a statement of the principle of conservation of momentum? 9702/01/O/N/03/Q9

A Momentum is the product of mass and velocity.

B In an elastic collision, momentum is constant.

C The momentum of an isolated system is constant.

D The force acting on a body is proportional to its rate of change of momentum.

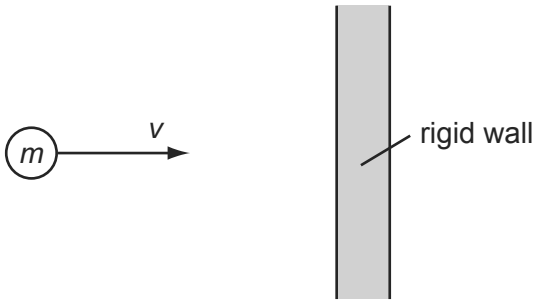
14 Two railway trucks of masses m and $3m$ move towards each other in opposite directions with speeds $2v$ and v respectively. These trucks collide and stick together. 9702/01/M/J/06/Q12

What is the speed of the trucks after the collision?

A $\frac{v}{4}$ **B** $\frac{v}{2}$ **C** v **D** $\frac{5v}{4}$

15 A particle of mass m strikes a vertical rigid wall perpendicularly from the left with velocity v.

9702/01/O/N/04/Q11



If the collision is perfectly elastic, the total change in momentum of the particle that occurs as a result of the collision is

A $2mv$ to the right.

B $2mv$ to the left.

C mv to the right.

D mv to the left.

16 Which is **not** one of Newton's laws of motion? 9702/01/M/J/05/Q10

A The total momentum of a system of interacting bodies remains constant, providing no external force acts.

B The rate of change of momentum of a body is directly proportional to the external force acting on the body and takes place in the direction of the force.

C If body A exerts a force on body B, then body B exerts an equal and oppositely-directed force on body A.

D A body continues in a state of rest or of uniform motion in a straight line unless acted upon by some external force.

17 A constant mass undergoes uniform acceleration. 9702/01/O/N/04/Q10

Which of the following is a correct statement about the resultant force acting on the mass?

A It increases uniformly with respect to time.

B It is constant but not zero.

C It is proportional to the displacement from a fixed point.

D It is proportional to the velocity.

18 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

19 Which is a statement of the principle of conservation of momentum? 9702/01/O/N/05/Q9

A A force is equal to the rate of change of momentum of the body upon which it acts.

B In a perfectly elastic collision, the relative momentum of the bodies before impact is equal to their relative momentum after impact.

C The momentum of a body is the product of the mass of the body and its velocity.

D The total momentum of a system of interacting bodies remains constant, providing no external force acts.

20 The gravitational field strength on the surface of planet P is one tenth of that on the surface of planet Q. 9702/01/O/N/05/Q10

On the surface of P, a body has its mass measured to be 1.0 kg and its weight measured to be 1.0 N.

What results are obtained for measurements of the mass and weight of the same body on the surface of planet Q?

	mass on Q	weight on Q
A	1.0 kg	0.1 N
B	1.0 kg	10 N
C	10 kg	10 N
D	10 kg	100 N

21 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

22 In perfectly elastic collisions between two atoms, it is always true to say that 9702/01/M/J/06/Q11

A the initial speed of one atom will be the same as the final speed of the other atom.

B the relative speed of approach between the two atoms equals their relative speed of separation.

C the total momentum must be conserved, but a small amount of the total kinetic energy may be lost in the collision.

D whatever their initial states of motion, neither atom can be stationary after the collision.

23 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/06/Q10

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

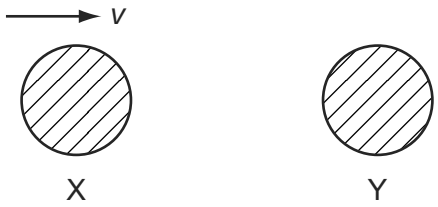
A a and v only

B a and F only

C v and F only

D v, F and a

24 The diagram shows two identical spheres X and Y. 9702/01/O/N/06/Q11

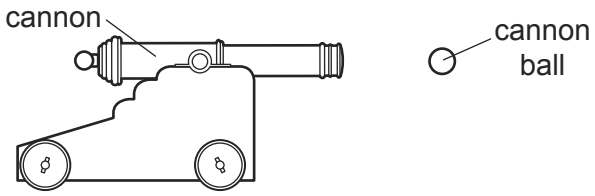


Initially X moves with speed v directly towards Y. Y is stationary. The spheres collide elastically.

What happens?

	X	Y
A	moves with speed $\frac{1}{2}v$ to the right	moves with speed $\frac{1}{2}v$ to the right
B	moves with speed v to the left	remains stationary
C	moves with speed $\frac{1}{2}v$ to the left	moves with speed $\frac{1}{2}v$ to the right
D	stops	moves with speed v to the right

25 The diagram shows a cannon ball fired from a cannon. 9702/01/O/N/06/Q12



The mass of the cannon is 1000 kg and the mass of the cannon ball is 10 kg.

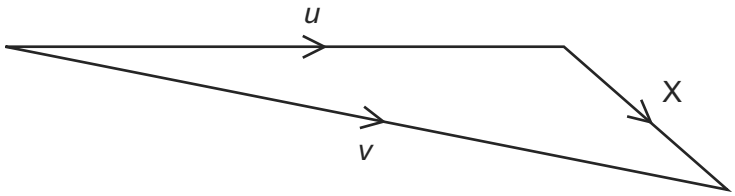
The recoil velocity of the cannon is $5\,m\,s^{-1}$ horizontally.

What is the horizontal velocity of the cannon ball?

A $200\,m\,s^{-1}$ **B** $500\,m\,s^{-1}$ **C** $2000\,m\,s^{-1}$ **D** $5000\,m\,s^{-1}$

26 An object has an initial velocity u. It is subjected to a constant force F for t seconds, causing a constant acceleration a. The force is **not** in the same direction as the initial velocity. 9702/01/M/J/07/Q7

A vector diagram is drawn to find the final velocity v.



What is the length of side X of the vector diagram?

A F **B** Ft **C** at **D** $u + at$

27 What is meant by the weight of an object? 9702/01/M/J/07/Q9

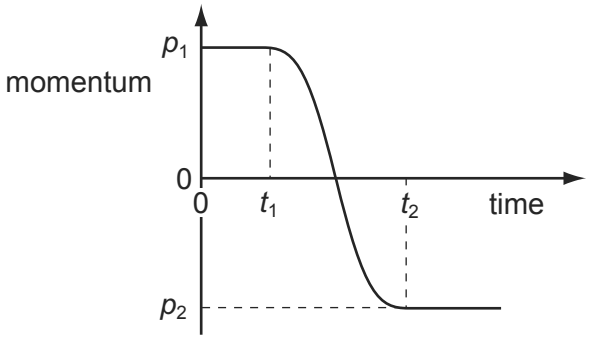
A the gravitational field acting on the object

B the gravitational force acting on the object

C the mass of the object multiplied by gravity

D the object's mass multiplied by its acceleration

28 The graph shows the variation with time of the momentum of a ball as it is kicked in a straight line. 9702/01/M/J/07/Q10



Initially, the momentum is p_1 at time t_1. At time t_2 the momentum is p_2.

What is the magnitude of the average force acting on the ball between times t_1 and t_2?

A $\frac{p_1 - p_2}{t_2}$ **B** $\frac{p_1 - p_2}{t_2 - t_1}$ **C** $\frac{p_1 + p_2}{t_2}$ **D** $\frac{p_1 + p_2}{t_2 - t_1}$

29 Which statement about Newton's laws of motion is correct? 9702/01/M/J/09/Q7

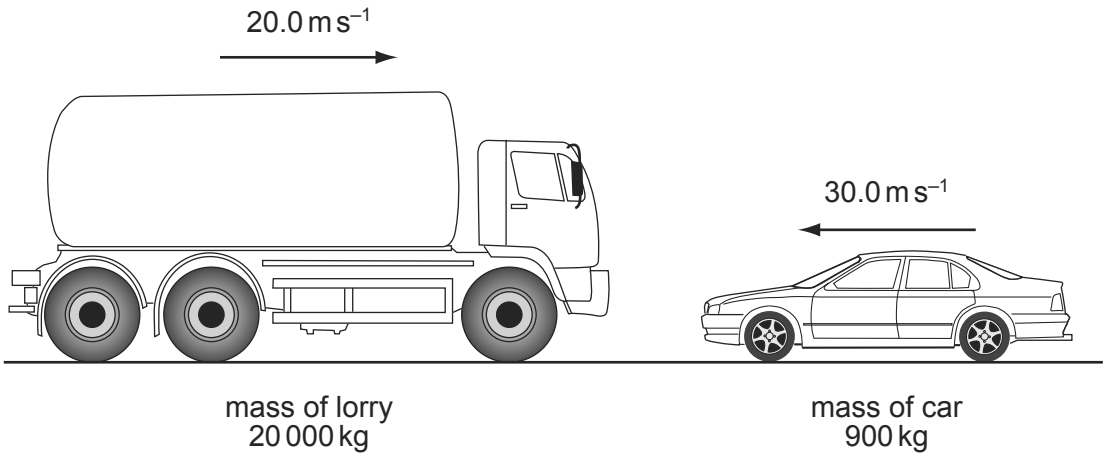
A The first law follows from the second law.

B The third law follows from the second law.

C Conservation of energy is a consequence of the third law.

D Conservation of linear momentum is a consequence of the first law.

30 A lorry of mass 20 000 kg is travelling at 20.0 m s^{-1}. A car of mass 900 kg is travelling at 30.0 m s^{-1} towards the lorry. 9702/01/M/J/07/Q11



What is the magnitude of the total momentum?

A 209 kN s **B** 373 kN s **C** 427 kN s **D** 1045 kN s

31 The diagram shows the masses and velocities of two trolleys about to collide. 9702/01/M/J/07/Q12



After the impact they move off together.

What is the total kinetic energy of the trolleys after the collision?

A 1.3 J **B** 12 J **C** 18 J **D** 19 J

32 Which is a statement of the principle of conservation of momentum? 9702/01/M/J/08/Q9

A Momentum is the product of mass and velocity.

B Momentum is conserved only in elastic collisions.

C Momentum is conserved by all bodies in a collision.

D Momentum is conserved providing no external forces act.

33 Which statement about a ball that strikes a tennis racket and rebounds is **always** correct? 9702/12/O/N/09/Q7

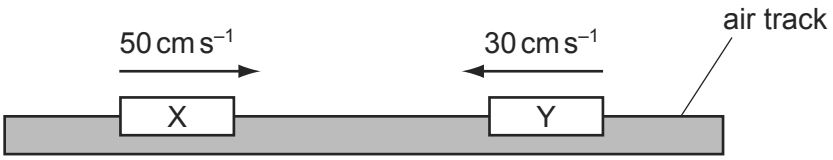
A Total kinetic energy of the ball is conserved.

B Total kinetic energy of the system is conserved.

C Total momentum of the ball is conserved.

D Total momentum of the system is conserved.

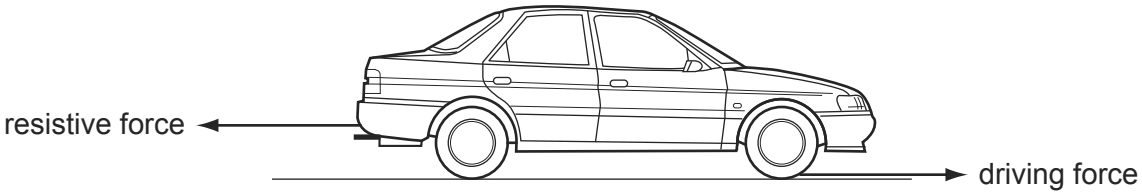
34 Two equal masses X and Y are moving towards each other on a frictionless air track as shown. The masses make an elastic collision. 9702/01/M/J/08/Q10



Which row gives possible velocities for the two masses after the collision?

	velocity of X	velocity of Y
A	zero	20 cm s^{-1} to the right
B	10 cm s^{-1} to the right	10 cm s^{-1} to the right
C	20 cm s^{-1} to the left	zero
D	30 cm s^{-1} to the left	50 cm s^{-1} to the right

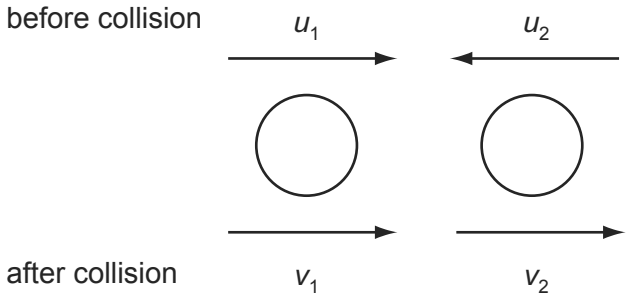
35 A car of mass 750 kg has a horizontal driving force of 2.0 kN acting on it. It has a forward horizontal acceleration of 2.0 m s^{-2}. 9702/01/M/J/08/Q11



What is the resistive force acting horizontally?

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

36 Two spheres approach each other along the same straight line. Their speeds are u_1 and u_2 before collision, and v_1 and v_2 after collision, in the directions shown below. 9702/01/O/N/08/Q10



Which equation is correct if the collision is perfectly elastic?

A $u_1 - u_2 = v_2 + v_1$

B $u_1 - u_2 = v_2 - v_1$

C $u_1 + u_2 = v_2 + v_1$

D $u_1 + u_2 = v_2 - v_1$

37 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?

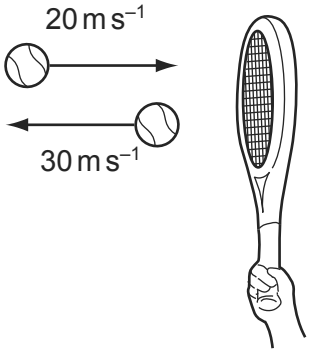
A The force that the ball exerts on the ground is always equal to the weight of the ball.

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.

38 A tennis ball of mass 100 g is struck by a tennis racket. The velocity of the ball is changed as shown. 9702/01/M/J/09/Q9

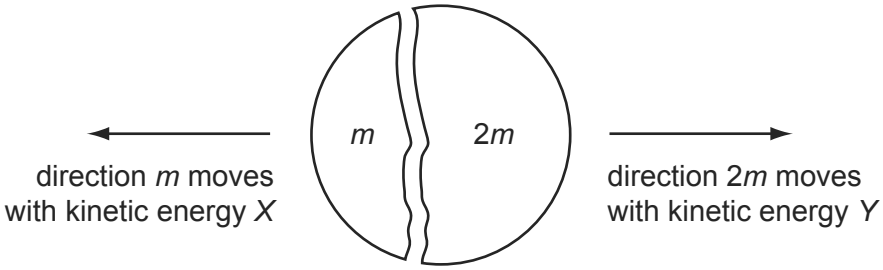


What is the magnitude of the change in momentum of the ball?

A 1 kg m s^{-1} **B** 5 kg m s^{-1} **C** 1000 kg m s^{-1} **D** 5000 kg m s^{-1}

39 A stationary body explodes into two components of masses m and $2m$. 9702/01/M/J/09/Q10

The components gain kinetic energies X and Y respectively.



What is the value of the ratio $\frac{X}{Y}$?

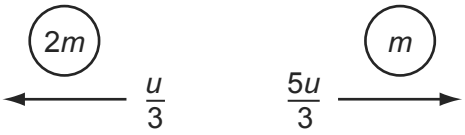
A $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** $\frac{2}{1}$ **D** $\frac{4}{1}$

40 The diagram shows two spherical masses approaching each other head-on at an equal speed u. One has mass $2m$ and the other has mass m. 9702/12/O/N/09/Q8

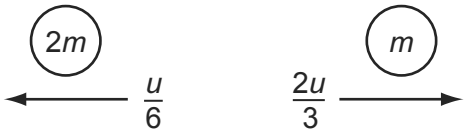


Which diagram, showing the situation after the collision, shows the result of an elastic collision?

A



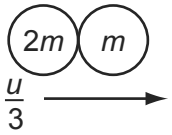
B



C



D



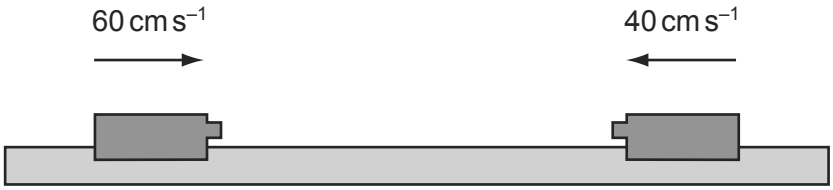
the spheres stick together

41 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}

42 Two equal masses travel towards each other on a frictionless air track at speeds of 60 cm s^{-1} and 40 cm s^{-1}. They stick together on impact. 9702/11/M/J/10/Q10



What is the speed of the masses after impact?

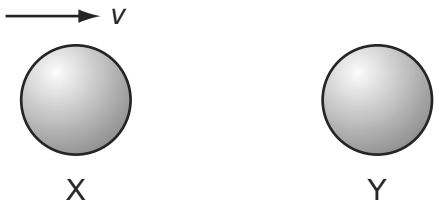
A 10 cm s^{-1} **B** 20 cm s^{-1} **C** 40 cm s^{-1} **D** 50 cm s^{-1}

43 A body, initially at rest, explodes into two masses M_1 and M_2 that move apart with speeds v_1 and v_2 respectively. 9702/11/O/N/10/Q11

What is the ratio $\frac{v_1}{v_2}$?

A $\frac{M_1}{M_2}$ **B** $\frac{M_2}{M_1}$ **C** $\sqrt{\frac{M_1}{M_2}}$ **D** $\sqrt{\frac{M_2}{M_1}}$

44 The diagram shows two identical spheres X and Y. 9702/11/M/J/10/Q12

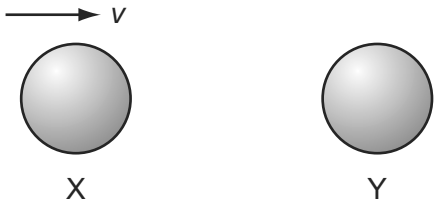


Initially, X moves with speed v directly towards Y. Y is stationary. The spheres collide elastically.

What happens?

	X	Y
A	moves with speed $\frac{1}{2}v$ to the right	moves with speed $\frac{1}{2}v$ to the right
B	moves with speed v to the left	remains stationary
C	moves with speed $\frac{1}{2}v$ to the left	moves with speed $\frac{1}{2}v$ to the right
D	stops	moves with speed v to the right

45 The diagram shows two identical spheres X and Y. 9702/13/M/J/10/Q9



Initially, X moves with speed v directly towards Y. Y is stationary. The spheres collide elastically.

What happens?

	X	Y
A	moves with speed $\frac{1}{2}v$ to the right	moves with speed $\frac{1}{2}v$ to the right
B	moves with speed v to the left	remains stationary
C	moves with speed $\frac{1}{2}v$ to the left	moves with speed $\frac{1}{2}v$ to the right
D	stops	moves with speed v to the right

46 Which defines the weight of a body? 9702/12/O/N/10/Q10

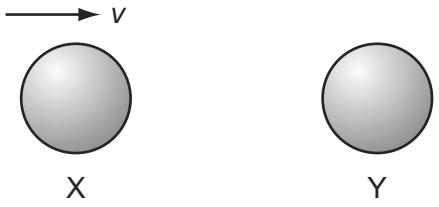
A the amount of matter in the body

B the force of gravity on the body

C the number of particles in the body

D the product of the body's volume and density

47 The diagram shows two identical spheres X and Y. 9702/12/M/J/10/Q10

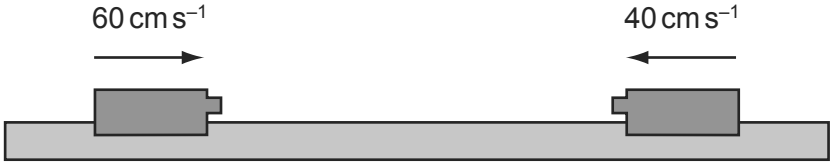


Initially, X moves with speed v directly towards Y. Y is stationary. The spheres collide elastically.

What happens?

	X	Y
A	moves with speed $\frac{1}{2}v$ to the right	moves with speed $\frac{1}{2}v$ to the right
B	moves with speed v to the left	remains stationary
C	moves with speed $\frac{1}{2}v$ to the left	moves with speed $\frac{1}{2}v$ to the right
D	stops	moves with speed v to the right

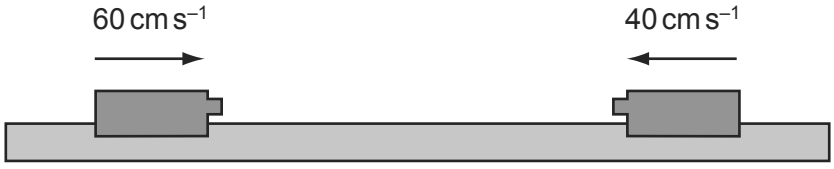
48 Two equal masses travel towards each other on a frictionless air track at speeds of $60\,\text{cm}\,\text{s}^{-1}$ and $40\,\text{cm}\,\text{s}^{-1}$. They stick together on impact. 9702/12/M/J/10/Q11



What is the speed of the masses after impact?

A $10\,\text{cm}\,\text{s}^{-1}$ **B** $20\,\text{cm}\,\text{s}^{-1}$ **C** $40\,\text{cm}\,\text{s}^{-1}$ **D** $50\,\text{cm}\,\text{s}^{-1}$

49 Two equal masses travel towards each other on a frictionless air track at speeds of $60\,\text{cm}\,\text{s}^{-1}$ and $40\,\text{cm}\,\text{s}^{-1}$. They stick together on impact. 9702/13/M/J/10/Q12



What is the speed of the masses after impact?

A $10\,\text{cm}\,\text{s}^{-1}$ **B** $20\,\text{cm}\,\text{s}^{-1}$ **C** $40\,\text{cm}\,\text{s}^{-1}$ **D** $50\,\text{cm}\,\text{s}^{-1}$

50 A molecule of mass m travelling horizontally with velocity u hits a vertical wall at right-angles to its velocity. It then rebounds horizontally with the same speed. 9702/11/M/J/11/Q10

What is its change in momentum?

A zero **B** mu **C** $-mu$ **D** $-2mu$

51 The gravitational field strength on the surface of planet P is one tenth of that on the surface of planet Q. 9702/11/O/N/10/Q10

On the surface of P, a body has a mass of 1.0 kg and a weight of 1.0 N.

What are the mass and weight of the same body on the surface of planet Q?

	mass on Q / kg	weight on Q / N
A	1.0	0.1
B	1.0	10
C	10	10
D	10	100

52 Two experiments are carried out using two trolleys of equal mass. All moving parts of the trolleys are frictionless, as is the surface that the trolleys move over. In both experiments, trolley X moves towards trolley Y, which is initially stationary. 9702/11/O/N/10/Q12



After the collision in experiment 1, X is stationary and Y moves off to the right.

After the collision in experiment 2, the trolleys join and move off together.

What types of collision occur in these experiments?

	experiment 1	experiment 2
A	elastic	elastic
B	elastic	inelastic
C	inelastic	elastic
D	inelastic	inelastic

53 A body, initially at rest, explodes into two masses M_1 and M_2 that move apart with speeds v_1 and v_2 respectively. 9702/13/O/N/10/Q9

What is the ratio $\frac{v_1}{v_2}$?

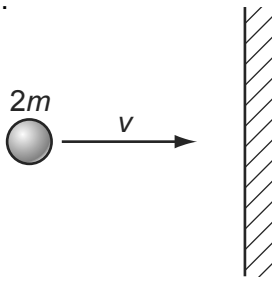
A $\frac{M_1}{M_2}$ **B** $\frac{M_2}{M_1}$ **C** $\sqrt{\frac{M_1}{M_2}}$ **D** $\sqrt{\frac{M_2}{M_1}}$

54 The momentum of an object changes from 160 kg m s^{-1} to 240 kg m s^{-1} in 2 s. 9702/12/M/J/11/Q11

What is the mean resultant force on the object during the change?

A 40 N **B** 80 N **C** 200 N **D** 400 N

55 A particle of mass $2m$ and velocity v strikes a wall. 9702/12/O/N/10/Q9



The particle rebounds along the same path after colliding with the wall. The collision is inelastic.

What is a possible change in the momentum of the ball during the collision?

A mv **B** $2mv$ **C** $3mv$ **D** $4mv$

56 The gravitational field strength on the surface of planet P is one tenth of that on the surface of planet Q. 9702/13/O/N/10/Q8

On the surface of P, a body has a mass of 1.0 kg and a weight of 1.0 N.

What are the mass and weight of the same body on the surface of planet Q?

	mass on Q / kg	weight on Q / N
A	1.0	0.1
B	1.0	10
C	10	10
D	10	100

57 Two experiments are carried out using two trolleys of equal mass. All moving parts of the trolleys are frictionless, as is the surface that the trolleys move over. In both experiments, trolley X moves towards trolley Y, which is initially stationary. 9702/13/O/N/10/Q10



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After the collision in experiment 2, the trolleys join and move off together.

What types of collision occur in these experiments?

	experiment 1	experiment 2
A	elastic	elastic
B	elastic	inelastic
C	inelastic	elastic
D	inelastic	inelastic

58 A body has a weight of 58.9 N when on the Earth. On the Moon, the acceleration of free fall is $1.64\,m\,s^{-2}$. 9702/11/M/J/11/Q8

What are the weight and the mass of the body when it is on the Moon?

	weight / N	mass / kg
A	9.85	1.00
B	9.85	6.00
C	58.9	1.00
D	58.9	6.00

59 A body of mass m, moving at velocity v, collides with a stationary body of the same mass and sticks to it. 9702/11/M/J/11/Q9

Which row describes the momentum and kinetic energy of the two bodies after the collision?

	momentum	kinetic energy
A	mv	$\frac{1}{4}mv^2$
B	mv	$\frac{1}{8}mv^2$
C	$2mv$	$\frac{1}{2}mv^2$
D	$2mv$	mv^2

60 A force F is applied to a freely moving object. At one instant of time, the object has velocity v and acceleration a. 9702/12/M/J/11/Q10

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

61 A car accelerates in a straight line. 9702/12/M/J/11/Q12

A graph of the momentum of the car is plotted against time.

What is evaluated by finding the gradient of the graph at a particular time?

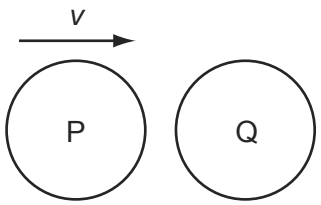
A the acceleration of the car

B the resultant force on the car

C the kinetic energy of the car

D the power supplied to the car

62 The diagram shows a particle P, travelling at speed v, about to collide with a stationary particle Q of the same mass. The collision is perfectly elastic. 9702/12/M/J/11/Q13



Which statement describes the motion of P and of Q immediately after the collision?

A P rebounds with speed $\frac{1}{2}v$ and Q acquires speed $\frac{1}{2}v$.

B P rebounds with speed v and Q remains stationary.

C P and Q both travel in the same direction with speed $\frac{1}{2}v$.

D P comes to a standstill and Q acquires speed v.

63 A molecule of mass m travelling horizontally with velocity u hits a vertical wall at right-angles to its velocity. It then rebounds horizontally with the same speed. 9702/13/M/J/11/Q9

What is its change in momentum?

A zero **B** mu **C** $-mu$ **D** $-2mu$

64 A body of mass m, moving at velocity v, collides with a stationary body of the same mass and sticks to it.

Which row describes the momentum and kinetic energy of the two bodies after the collision? 9702/13/M/J/11/Q10

	momentum	kinetic energy
A	mv	$\frac{1}{4}mv^2$
B	mv	$\frac{1}{8}mv^2$
C	$2mv$	$\frac{1}{2}mv^2$
D	$2mv$	mv^2

65 A body has a weight of 58.9 N when on the Earth. On the Moon, the acceleration of free fall is $1.64\,\text{m}\,\text{s}^{-2}$. 9702/13/M/J/11/Q6

What are the weight and the mass of the body when it is on the Moon?

	weight / N	mass / kg
A	9.85	1.00
B	9.85	6.00
C	58.9	1.00
D	58.9	6.00

66 What is the **definition** of the force on a body? 9702/11/O/N/11/Q10

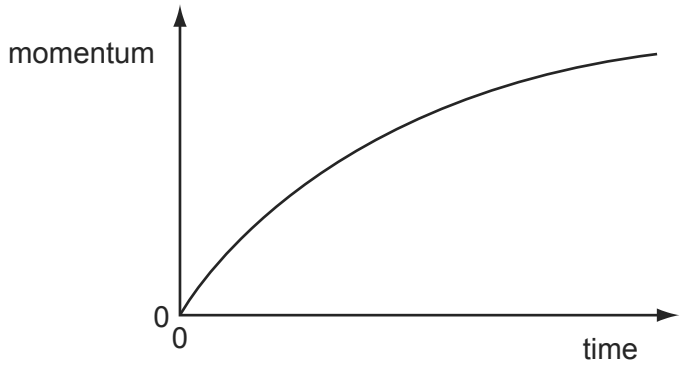
A the mass of the body multiplied by its acceleration

B the power input to the body divided by its velocity

C the rate of change of momentum of the body

D the work done on the body divided by its displacement

67 A car accelerates from rest. The graph shows the momentum of the car plotted against time. 9702/11/O/N/11/Q11



What is the meaning of the gradient of the graph at a particular time?

A the resultant force on the car

B the velocity of the car

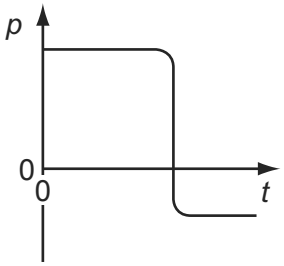
C the kinetic energy of the car

D the rate of change of kinetic energy of the car

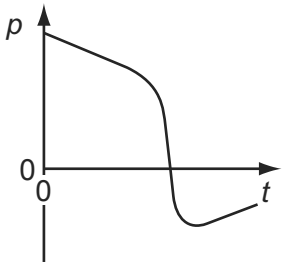
68 An ice-hockey puck slides along a horizontal, frictionless ice-rink surface. It collides inelastically with a wall at right angles to its path, and then rebounds along its original path. 9702/11/O/N/11/Q12

Which graph shows the variation with time t of the momentum p of the puck?

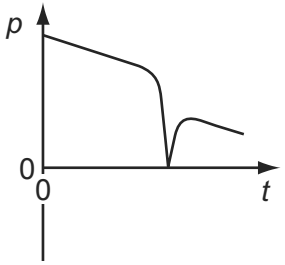
A



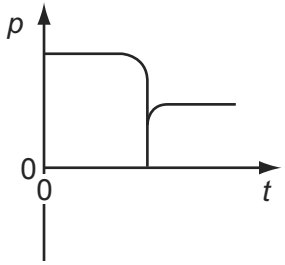
B



C



D



69 An object of mass 20 kg is travelling at a constant speed of 6.0 m s^{-1}. 9702/12/O/N/11/Q11

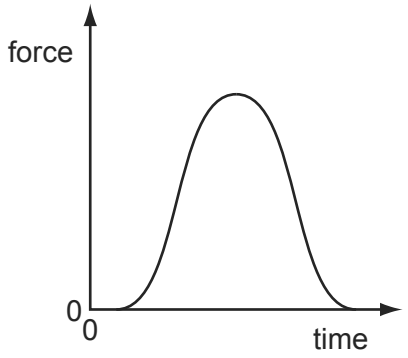
It collides with an object of mass 12 kg travelling at a constant speed of 15 m s^{-1} in the opposite direction. The objects stick together.

What is the speed of the objects immediately after the collision?

A 1.9 m s^{-1} **B** 9.0 m s^{-1} **C** 9.4 m s^{-1} **D** 21 m s^{-1}

70 A golf ball is hit by a club. The graph shows the variation with time of the force exerted on the ball by the club.

9702/12/O/N/11/Q9



Which quantity, for the time of contact, **cannot** be found from the graph?

A the average force on the ball

B the change in momentum of the ball

C the contact time between the ball and the club

D the maximum acceleration of the ball

71 A group of students investigating the principle of conservation of momentum use a small truck travelling over a frictionless surface.

9702/12/O/N/11/Q10

Sand is dropped into the truck as it passes X. At Y, a trapdoor in the bottom of the truck opens and the sand falls out.



How does the velocity of the truck change when the sand is added to the truck at X and then leaves the truck at Y?

	at X	at Y
A	decreases	increases
B	decreases	stays the same
C	stays the same	increases
D	stays the same	stays the same

72 What is the **definition** of the force on a body?

A the mass of the body multiplied by its acceleration

B the power input to the body divided by its velocity

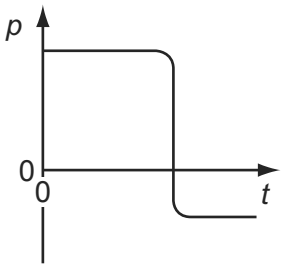
C the rate of change of momentum of the body

D the work done on the body divided by its displacement

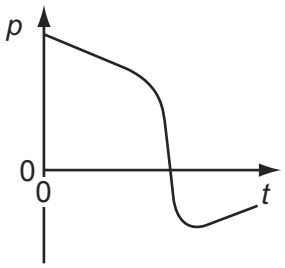
73 An ice-hockey puck slides along a horizontal, frictionless ice-rink surface. It collides inelastically with a wall at right angles to its path, and then rebounds along its original path. 9702/13/O/N/11/Q10

Which graph shows the variation with time t of the momentum p of the puck?

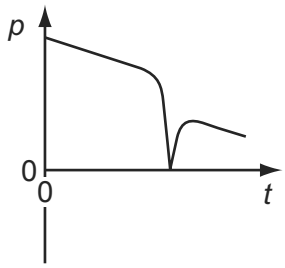
A



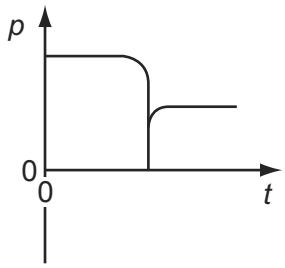
B



C

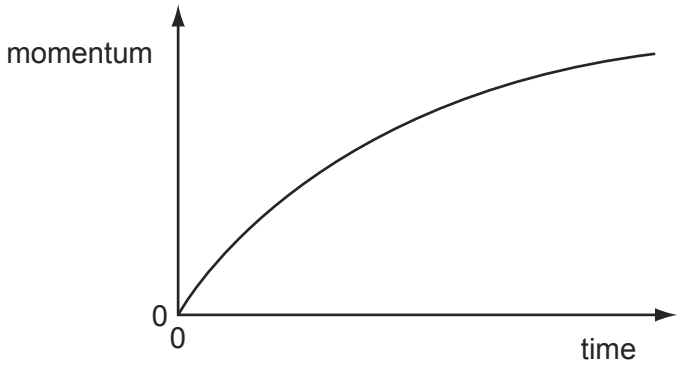


D



74 A car accelerates from rest. The graph shows the momentum of the car plotted against time.

9702/13/O/N/11/Q12



What is the meaning of the gradient of the graph at a particular time?

A the resultant force on the car

B the velocity of the car

C the kinetic energy of the car

D the rate of change of kinetic energy of the car

75 Which row correctly states whether momentum and kinetic energy are conserved in an inelastic collision in which there are no external forces? 9702/12/M/J/12/Q11

	momentum	kinetic energy
A	conserved	conserved
B	conserved	not conserved
C	not conserved	conserved
D	not conserved	not conserved

76 Two spheres approach each other along the same straight line. Their speeds are u_1 and u_2 before collision. After the collision, the spheres separate with speeds v_1 and v_2 in the directions shown below. 9702/12/M/J/12/Q12



Which equation must be correct if the collision is perfectly elastic?

A $u_1 - u_2 = v_2 + v_1$

B $u_1 - u_2 = v_2 - v_1$

C $u_1 + u_2 = v_2 + v_1$

D $u_1 + u_2 = v_2 - v_1$

77 Each option gives a correct word equation involving force. 9702/12/M/J/12/Q10

Which option gives the definition of force?

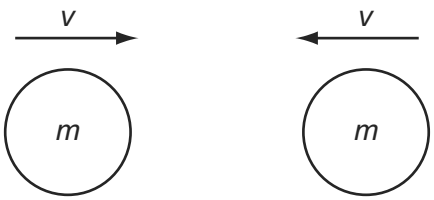
A force = energy divided by displacement

B force = mass × acceleration

C force = pressure × area

D force = rate of change of momentum

78 Two similar spheres, each of mass m and travelling with speed v, are moving towards each other. 9702/12/M/J/12/Q11



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 $2mv$.

79 Each option gives a correct word equation involving force. 9702/13/M/J/12/Q11

Which option gives the definition of force?

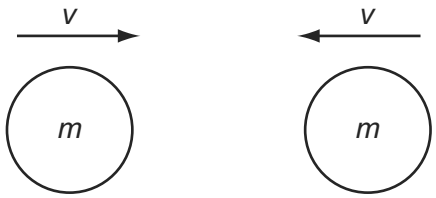
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80 Two similar spheres, each of mass *m* and travelling with speed *v*, are moving towards each other. 9702/13/M/J/12/Q12



The spheres have a head-on elastic collision.

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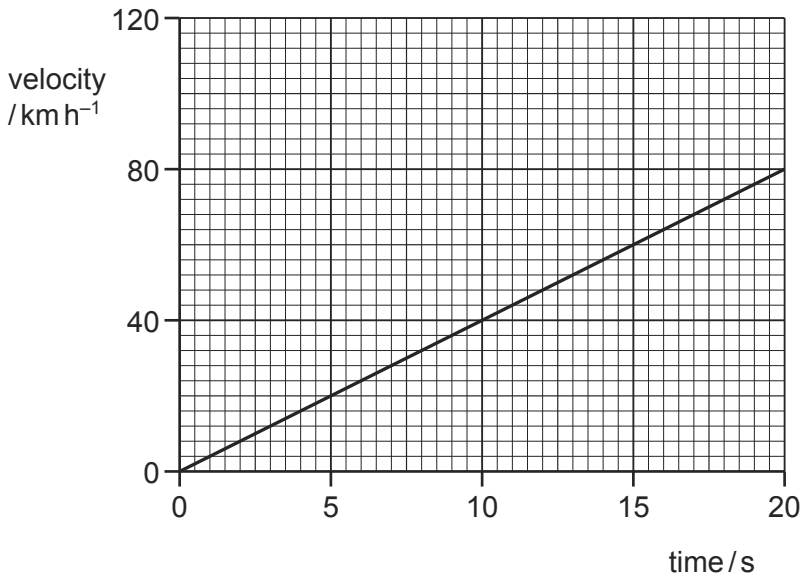
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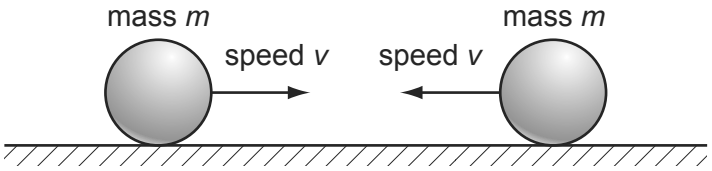
81 The velocity of a car changes as shown. 9702/12/O/N/12/Q11



What is the acceleration of the car?

A 1.1 m s^{-2} **B** 4.0 m s^{-2} **C** 224 m s^{-2} **D** 800 m s^{-2}

82 Two identical, perfectly elastic spheres have the same mass m. They travel towards each other with the same speed v along a horizontal frictionless surface. 9702/12/O/N/12/Q13



Which statement about the sum of the kinetic energies of the spheres is correct?

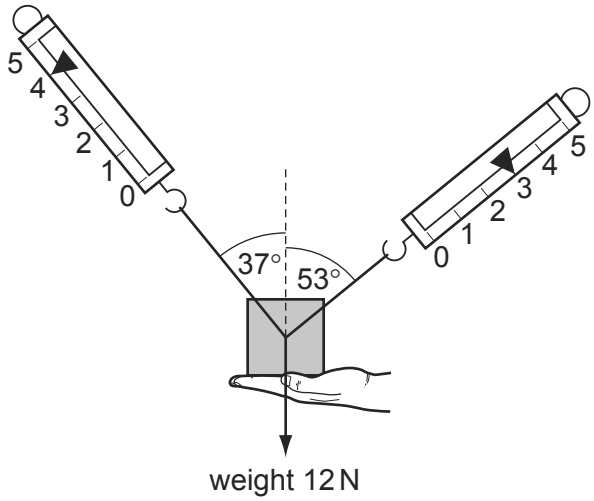
A The sum of their kinetic energies before impact is zero.

B The sum of their kinetic energies before impact is $\frac{1}{2}mv^2$.

C The sum of their kinetic energies after impact is zero.

D The sum of their kinetic energies after impact is mv^2.

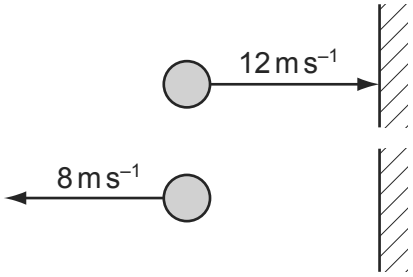
83 A 1.2 kg mass is supported by a person's hand and two newton-meters as shown. 9702/12/O/N/12/Q14



When the person's hand is removed, what is the initial vertical acceleration of the mass?

A $0.6\,m\,s^{-2}$ **B** $2\,m\,s^{-2}$ **C** $4\,m\,s^{-2}$ **D** $6\,m\,s^{-2}$

84 A ball of mass 0.5 kg is thrown against a wall at a speed of $12\,m\,s^{-1}$. It bounces back with a speed of $8\,m\,s^{-1}$. The collision lasts for 0.10 s. 9702/12/O/N/12/Q12



What is the average force on the ball due to the collision?

A 0.2 N **B** 1 N **C** 20 N **D** 100 N

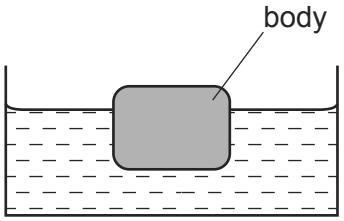
85 A lorry of mass 20 000 kg has a constant resultant force F acting on it. 9702/12/O/N/12/Q15

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

86 A stationary body floats in water. 9702/12/O/N/12/Q16



Which statement about the forces acting on the body is correct?

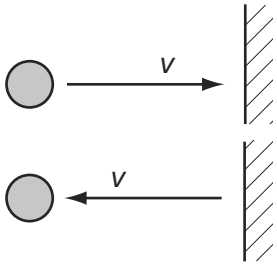
A The gravitational force is equal to the viscous force.

B The gravitational force is greater than the upthrust.

C The upthrust is zero.

D The viscous force is zero.

87 An object travelling with velocity v strikes a wall and rebounds as shown. 9702/11/O/N/12/Q11



Which property of the object is **not** conserved?

A kinetic energy

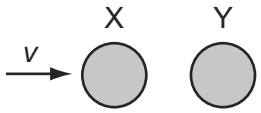
B mass

C momentum

D speed

88 A particle X has speed v and collides with a stationary identical particle Y. The collision is perfectly elastic.

9702/11/O/N/12/Q12

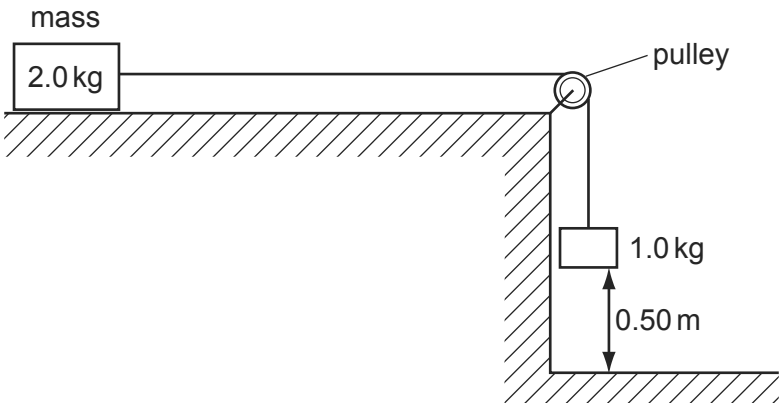


What are the speed and direction of motion of each of the two particles after the collision?

	X	Y
A	stationary	v to the right
B	$\frac{v}{2}$ to the right	$\frac{v}{2}$ to the right
C	$\frac{v}{2}$ to the left	$\frac{v}{2}$ to the right
D	v to the left	stationary

89 A mass of 2.0 kg rests on a frictionless surface. It is attached to a 1.0 kg mass by a light, thin string which passes over a frictionless pulley. The 1.0 kg mass is released and it accelerates downwards.

9702/11/O/N/12/Q13

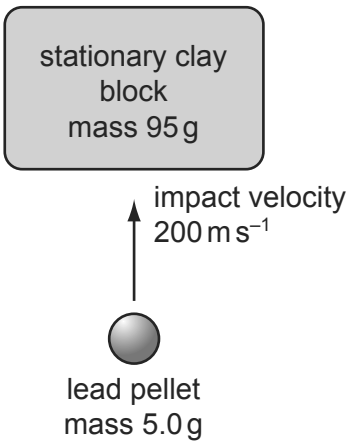


What is the speed of the 2.0 kg mass as the 1.0 kg mass hits the floor, having fallen a distance of 0.50 m?

A $1.8\,\text{m s}^{-1}$ **B** $2.2\,\text{m s}^{-1}$ **C** $3.1\,\text{m s}^{-1}$ **D** $9.8\,\text{m s}^{-1}$

90 A lead pellet is shot vertically upwards into a clay block that is stationary at the moment of impact but is able to rise freely after impact.

9702/11/O/N/12/Q14



The pellet hits the block with an initial velocity of 200 m s^{-1}. It embeds itself in the block and does not emerge.

How high above its initial position will the block rise?
(Mass of pellet = 5.0 g; mass of clay block = 95 g.)

A 5.1 m **B** 5.6 m **C** 10 m **D** 2000 m

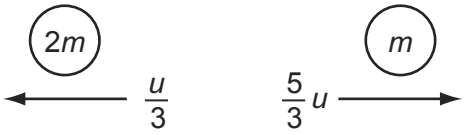
91 The diagram shows two spherical masses approaching each other head-on at an equal speed u. One is of mass m and the other of mass $2m$.

9702/13/O/N/12/Q11

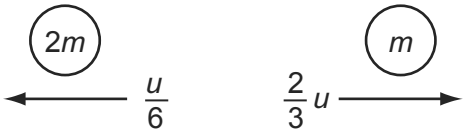


Which diagram, showing the situation after the collision, is **not** consistent with the principle of conservation of momentum?

A



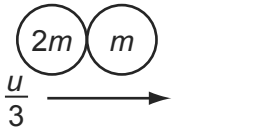
B



C



D



the spheres stick together

92 A molecule of mass m travelling at speed v hits a wall in a direction perpendicular to the wall. The collision is elastic. 9702/13/O/N/12/Q12

What are the changes in the kinetic energy and in the momentum of the molecule caused by the collision?

	change in momentum	change in kinetic energy
A	0	0
B	0	mv^2
C	$2mv$	0
D	mv^2	0

93 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 1.0×10^{-5} N m^{-2}. 9702/13/O/N/12/Q13

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

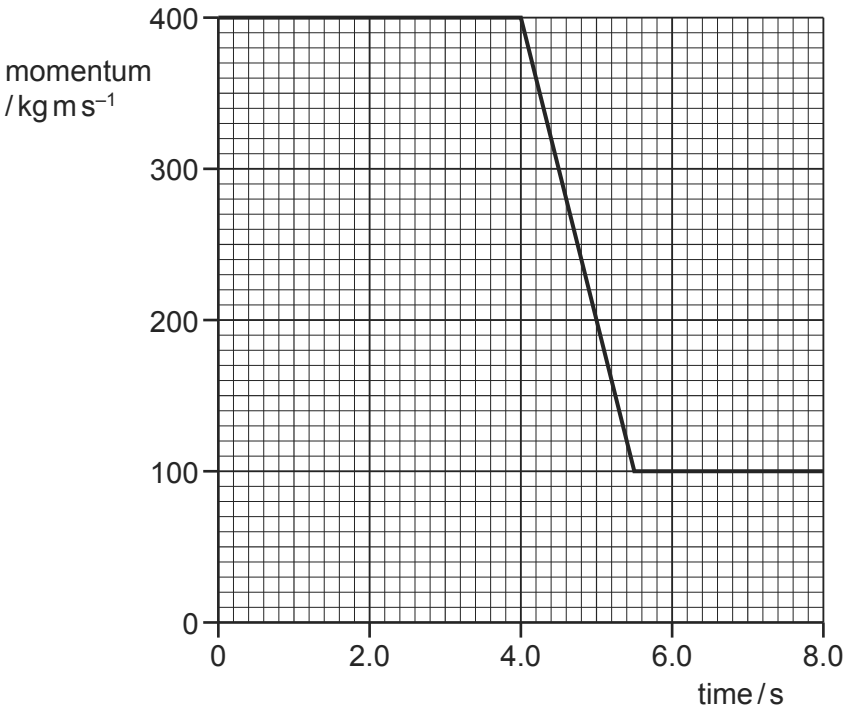
A 3.1×10^{-8} m s^{-2}

B 6.3×10^{-7} m s^{-2}

C 3.2×10^{-3} m s^{-2}

D 6.4×10^{-2} m s^{-2}

94 The graph shows the momentum of a cyclist over a period of 8.0 s. 9702/13/O/N/12/Q14



At time 4.0 s, she applies the brakes.

What is the resultant force on the cyclist during the period when the brakes are applied?

A 55 N **B** 200 N **C** 270 N **D** 450 N

95 Which of the following is a statement of the principle of conservation of momentum? 9702/11/M/J/13/Q10

A In an elastic collision momentum is constant.

B Momentum is the product of mass and velocity.

C The force acting on a body is proportional to its rate of change of momentum.

D The momentum of an isolated system is constant.

96 A stationary nucleus has nucleon number A. 9702/13/M/J/13/Q10

The nucleus decays by emitting a proton with speed v to form a new nucleus with speed u. The new nucleus and the proton move away from one another in opposite directions.

Which equation gives v in terms of A and u?

A $v = (\frac{A}{4} - 1)u$

B $v = (A - 1)u$

C $v = Au$

D $v = (A + 1)u$

97 A strong wind of speed $33\,m\,s^{-1}$ blows against a wall. The density of the air is $1.2\,kg\,m^{-3}$. The wall has an area of $12\,m^2$ at right angles to the wind velocity. The air has its speed reduced to zero when it hits the wall. 9702/12/M/J/13/Q9

What is the approximate force exerted by the air on the wall?

A 330 N **B** 400 N **C** 480 N **D** 16 000 N

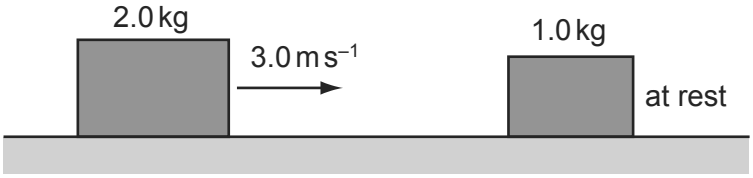
98 Two spheres travel along the same line with velocities u_1 and u_2. They collide and after collision their velocities are v_1 and v_2. 9702/13/M/J/13/Q11



Which collision is **not** elastic?

	u_1 / m s^{-1}	u_2 / m s^{-1}	v_1 / m s^{-1}	v_2 / m s^{-1}
A	2	–5	–5	–2
B	3	–3	0	6
C	3	–2	1	6
D	5	2	3	6

99 A 2.0 kg mass travelling at 3.0 m s^{-1} on a frictionless surface collides head-on with a stationary 1.0 kg mass. The masses stick together on impact. 9702/11/M/J/13/Q11



How much kinetic energy is lost on impact?

A zero **B** 2.0 J **C** 2.4 J **D** 3.0 J

100 Two bodies travelling in a straight line collide in a perfectly elastic collision. Which of the following statements **must** be correct? 9702/12/M/J/13/Q10

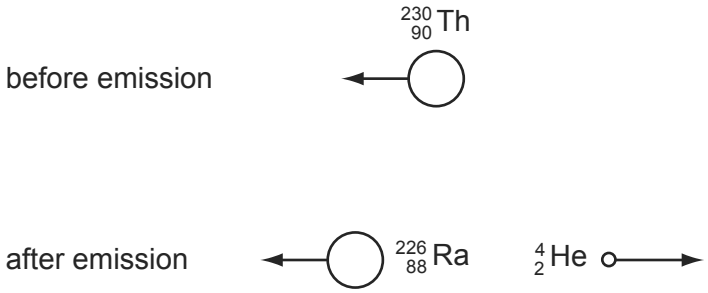
A The initial speed of one body will be the same as the final speed of the other body.

B The relative speed of approach between the two bodies equals their relative speed of separation.

C The total momentum is conserved but the total kinetic energy will be reduced.

D One of the bodies will be stationary at one instant.

101 A moving thorium nucleus $^{230}_{90}\text{Th}$ spontaneously emits an α-particle. The nucleus formed is a radium nucleus $^{226}_{88}\text{Ra}$, as shown. 9702/13/O/N/13/Q10



Which statement is correct?

A The kinetic energy of the α-particle equals the kinetic energy of the radium nucleus.

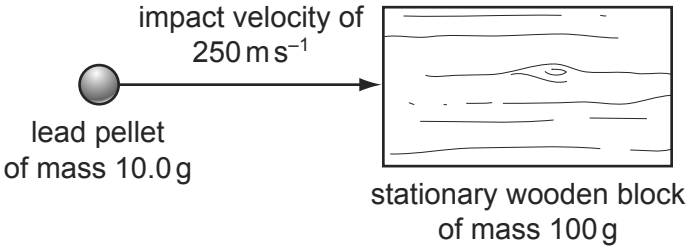
B The momentum of the α-particle equals the momentum of the radium nucleus.

C The total momentum before the emission equals the total momentum after the emission.

D The velocity of the α-particle equals the velocity of the radium nucleus.

102 A lead pellet of mass 10.0 g is shot horizontally into a stationary wooden block of mass 100 g. The pellet hits the block with an impact velocity of 250 m s^{-1}. It embeds itself in the block and it does not emerge.

9702/13/O/N/13/Q13



What will be the speed of the block immediately after the pellet is embedded?

A 23 m s^{-1} **B** 25 m s^{-1} **C** 75 m s^{-1} **D** 79 m s^{-1}

103 A beam of α-particles collides with a lead sheet. Each α-particle in the beam has a mass of 6.6×10^{-27} kg and a speed of 1.5×10^{7} m s^{-1}.

9702/11/O/N/13/Q11

5.0×10^{4} α-particles per second collide with an area of 1.0 cm^2 of lead. Almost all of the α-particles are absorbed by the lead so that they have zero speed after collision.

What is an estimate of the average pressure exerted on the lead by the α-particles?

A 5.0×10^{-15} Pa

B 5.0×10^{-13} Pa

C 5.0×10^{-11} Pa

D 5.0×10^{-9} Pa

104 An isolated system consists of two bodies on which no external forces act. The two bodies collide with each other and stick together on impact.

9702/13/O/N/13/Q11

Which row correctly compares the total kinetic energy and the total momentum of the bodies before and after the collision?

	total kinetic energy before and after the collision	total momentum before and after the collision
A	different	different
B	different	the same
C	the same	different
D	the same	the same

105 An object of mass 4.0 kg moving with a speed of 3.0 m s^{-1} strikes a stationary object in an inelastic collision. 9702/11/M/J/14/Q9

Which statement is correct?

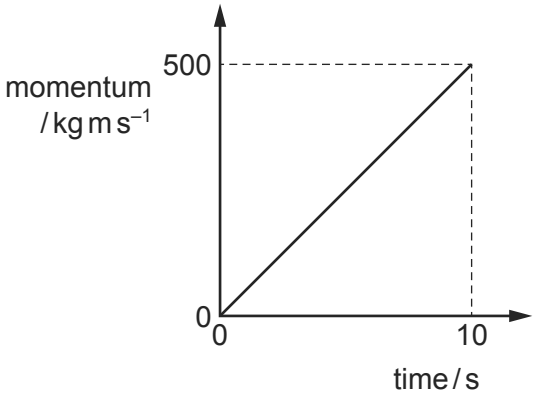
A After collision, the total kinetic energy is 18 J.

B After collision, the total kinetic energy is less than 18 J.

C Before collision, the total kinetic energy is 12 J.

D Before collision, the total kinetic energy is less than 12 J.

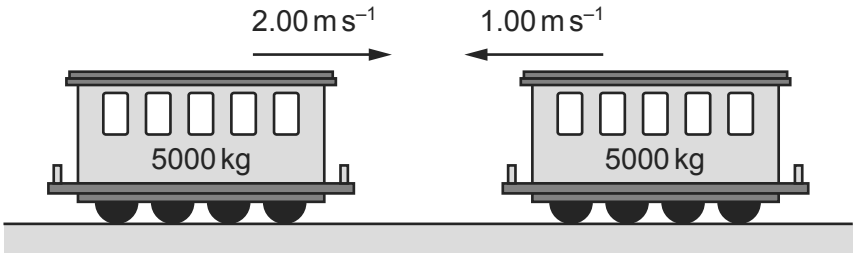
106 The graph shows how the momentum of a motorcycle changes with time. 9702/11/M/J/14/Q10



What is the resultant force on the motorcycle?

A 50 N **B** 500 N **C** 2500 N **D** 5000 N

107 Two train carriages each of mass 5000 kg roll toward one another on a level track. One is travelling at 2.00 m s^{-1} and the other at 1.00 m s^{-1}, as shown. 9702/12/M/J/14/Q7



They collide and join together.

What is the kinetic energy lost during the collision?

A 1250 J **B** 7500 J **C** 11 250 J **D** 12 500 J

108 A resultant force causes a body to accelerate. 9702/12/M/J/14/Q8

What is equal to the resultant force?

A the acceleration of the body per unit mass

B the change in kinetic energy of the body per unit time

C the change in momentum of the body per unit time

D the change in velocity of the body per unit time

109 A ship of mass 8.4×10^7 kg is approaching a harbour with speed $16.4\,m\,s^{-1}$. By using reverse thrust it can maintain a constant total stopping force of 920 000 N. 9702/12/M/J/14/Q9

How long will it take to stop?

A 15 seconds

B 150 seconds

C 25 minutes

D 250 minutes

110 A tractor of mass 1000 kg is connected by a tow-bar to a trailer of mass 1000 kg. The total resistance to motion has a constant value of 4000 N. One quarter of this resistance acts on the trailer. 9702/12/M/J/14/Q10

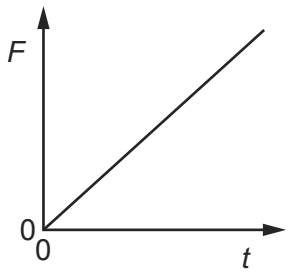
When the tractor and trailer are moving along horizontal ground at a constant speed of $6\,m\,s^{-1}$, what is the force exerted on the tractor by the tow-bar?

A 0 N **B** 1000 N **C** 3000 N **D** 4000 N

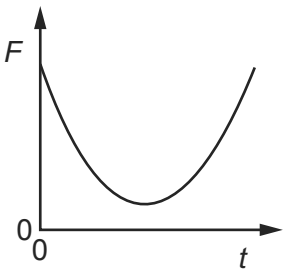
111 A tennis ball is dropped onto a table and bounces back up. The table exerts a force F on the ball.

Which graph best shows the variation with time t of the force F while the ball is in contact with the table? 9702/13/M/J/14/Q10

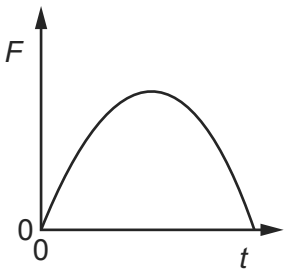
A



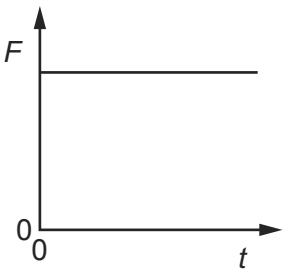
B



C

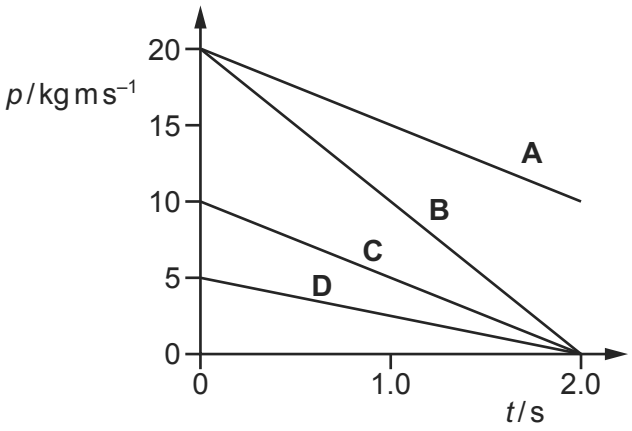


D



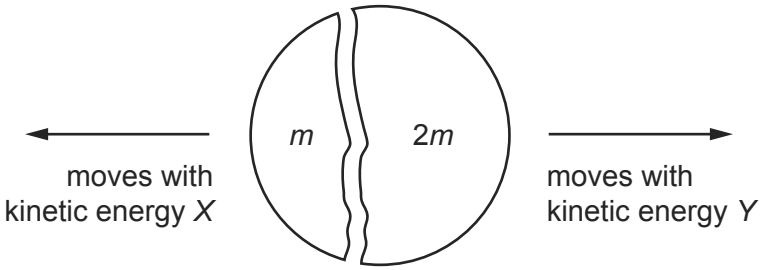
112 A resultant force of 10 N acts on a body for a time of 2.0 s. 9702/13/M/J/14/Q11

Which graph could show the variation with time t of the momentum p of the body?



113 A stationary body explodes into two components of masses m and $2m$. 9702/13/M/J/14/Q12

The components gain kinetic energies X and Y respectively.

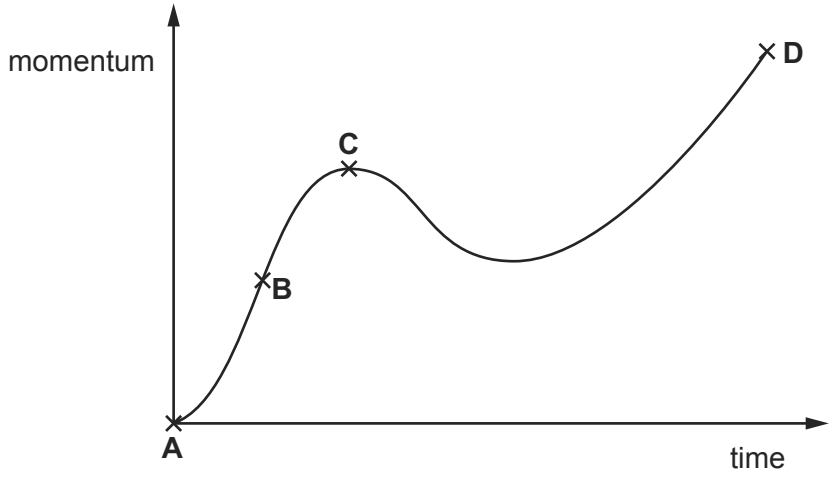


What is the value of the ratio $\frac{X}{Y}$?

A $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** $\frac{2}{1}$ **D** $\frac{4}{1}$

114 A body experiences a varying resultant force that causes its momentum to vary, as shown in the graph. 9702/13/O/N/14/Q10

At which point does the resultant force have the largest value?



115 A golf ball of mass m is dropped onto a hard surface from a height h_1 and rebounds to a height h_2. 9702/13/O/N/14/Q11

The momentum of the golf ball just as it reaches the surface is different from its momentum just as it leaves the surface.

What is the total change in the momentum of the golf ball between these two instants? (Ignore air resistance.)

A $m\sqrt{2gh_1} - m\sqrt{2gh_2}$

B $m\sqrt{2gh_1} + m\sqrt{2gh_2}$

C $m\sqrt{2g(h_1 - h_2)}$

D $m\sqrt{2g(h_1 + h_2)}$

116 The diagram shows a particle X, with kinetic energy E_k, about to collide with a stationary particle Y. Both particles have the same mass. 9702/13/O/N/14/Q16



After colliding, X and Y travel onwards together as a single larger particle.

How much kinetic energy is lost in the collision?

A 0 **B** $\frac{E_k}{4}$ **C** $\frac{E_k}{2}$ **D** $\frac{3E_k}{4}$

117 Two railway trucks of masses m and $3m$ move towards each other in opposite directions with speeds $2v$ and v respectively. These trucks collide and stick together. 9702/11/O/N/14/Q9

What is the speed of the trucks after the collision?

A $\frac{v}{4}$ **B** $\frac{v}{2}$ **C** v **D** $\frac{5v}{4}$

118 What is the principle of conservation of momentum? 9702/11/O/N/14/Q7

A Force is equal to the rate of change of momentum.

B Momentum is the product of mass and velocity.

C The total momentum of a system remains constant provided no external force acts on it.

D The total momentum of two bodies after collision is equal to their total momentum before collision.

119 Water is pumped through a hose-pipe at a rate of 90 kg per minute. It emerges from the hose-pipe horizontally with a speed of 20 m s^{-1}. 9702/11/O/N/14/Q8

Which force is required from a person holding the hose-pipe to prevent it moving backwards?

A 30 N **B** 270 N **C** 1800 N **D** 10 800 N

120 Which of the following is a statement of the principle of conservation of momentum? 9702/13/M/J/15/Q10

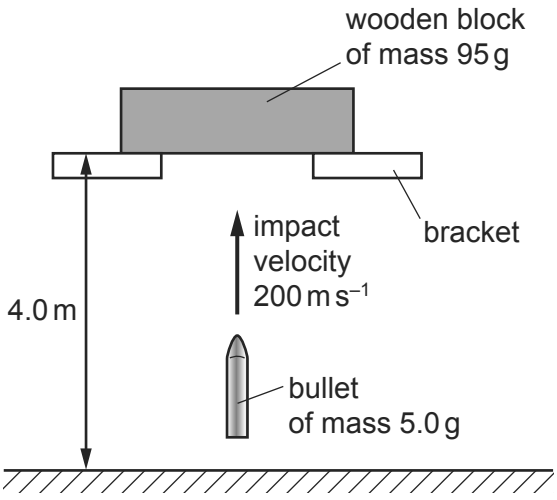
A Momentum is the product of mass and velocity.

B In an elastic collision, momentum is constant.

C The momentum of an isolated system is constant.

D The force acting on a body is proportional to its rate of change of momentum.

121 A wooden block is freely supported on brackets at a height of 4.0 m above the ground, as shown. 9702/13/M/J/15/Q13



A bullet of mass 5.0 g is shot vertically upwards into the wooden block of mass 95 g. It embeds itself in the block. The impact causes the block to rise above its supporting brackets.

The bullet hits the block with a velocity of 200 m s^{-1}. How far above the ground will the block be at the maximum height of its path?

A 5.1 m **B** 5.6 m **C** 9.1 m **D** 9.6 m

122 A moving object strikes a stationary object. The collision is inelastic. The objects move off together.

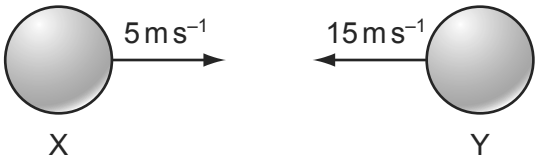
9702/13/M/J/15/Q11

Which row shows the possible values of total momentum and total kinetic energy for the system before and after the collision?

	total momentum before collision / kg m s^{-1}	total momentum after collision / kg m s^{-1}	total kinetic energy before collision / J	total kinetic energy after collision / J
A	6	2	90	30
B	6	6	30	90
C	6	6	90	30
D	6	6	90	90

123 Two balls X and Y are moving towards each other with speeds of 5 m s^{-1} and 15 m s^{-1} respectively.

9702/13/M/J/15/Q12



They make a perfectly elastic head-on collision and ball Y moves to the right with a speed of 7 m s^{-1}.

What is the speed and direction of ball X after the collision?

A 3 m s^{-1} to the left

B 13 m s^{-1} to the left

C 3 m s^{-1} to the right

D 13 m s^{-1} to the right

124 A firework rocket is fired vertically upwards. The fuel burns and produces a constant upwards force on the rocket. After 5 seconds there is no fuel left. Air resistance is negligible.

9702/12/M/J/15/Q10

What is the acceleration before and after 5 seconds?

	before 5 seconds	after 5 seconds
A	constant	constant
B	constant	zero
C	increasing	constant
D	increasing	zero

125 Trolley X, moving along a horizontal frictionless track, collides with a stationary trolley Y. The two trolleys become attached and move off together. 9702/12/M/J/15/Q11

Which statement about this interaction is correct?

A Some of the kinetic energy of trolley X is changed to momentum in the collision.

B Some of the momentum of trolley X is changed to kinetic energy in the collision.

C Trolley X loses some of its momentum as heat in the collision.

D Trolley X shares its momentum with trolley Y but some of its kinetic energy is lost.

126 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

127 A molecule of mass m travelling at speed v hits a wall in a direction perpendicular to the wall. The collision is elastic. 9702/11/M/J/15/Q11

What are the changes in the momentum and in the kinetic energy of the molecule caused by the collision?

	change in momentum	change in kinetic energy
A	0	0
B	0	mv^2
C	$2mv$	0
D	mv^2	0

128 What is the **definition** of the force on a body? 9702/11/M/J/15/Q14

A the mass of the body multiplied by its acceleration

B the power input to the body divided by its velocity

C the rate of change of momentum of the body

D the work done on the body divided by its displacement

Q1.

1 **(a)** State the difference between a scalar quantity and a vector quantity.

scalar: .....

.....

vector: .....

..... [2]

(b) Two forces of magnitude 6.0 N and 8.0 N act at a point P. Both forces act away from point P and the angle between them is 40°.
Fig. 1.1 shows two lines at an angle of 40° to one another.

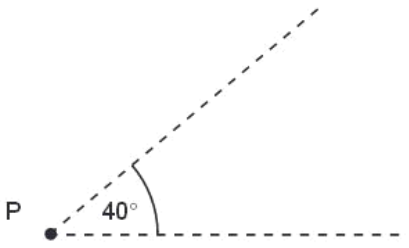


Fig. 1.1

On Fig. 1.1, draw a vector diagram to determine the magnitude of the resultant of the two forces.

magnitude of resultant = ... N [4]

Q2.

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4 A ball has mass m. It is dropped onto a horizontal plate as shown in Fig. 4.1.

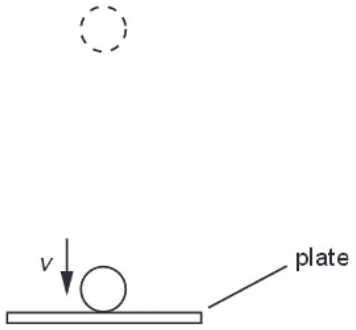


Fig. 4.1

Just as the ball makes contact with the plate, it has velocity v, momentum p and kinetic energy E_k.

(a) (i) Write down an expression for momentum p in terms of m and v.

.....

(ii) Hence show that the kinetic energy is given by the expression

$$E_k = \frac{p^2}{2m}.$$

[3]

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(b) Just before impact with the plate, the ball of mass 35 g has speed 4.5 m s^{-1}. It bounces from the plate so that its speed immediately after losing contact with the plate is 3.5 m s^{-1}. The ball is in contact with the plate for 0.14 s.

Calculate, for the time that the ball is in contact with the plate,

(i) the average force, in addition to the weight of the ball, that the plate exerts on the ball,

magnitude of force = ... N

direction of force = ...
[4]

(ii) the loss in kinetic energy of the ball.

loss = ... J [2]

(c) State and explain whether linear momentum is conserved during the bounce.

.....

.....

.....

..... [3]

Q3.

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5 Two forces, each of magnitude F, form a couple acting on the edge of a disc of radius r, as shown in Fig. 5.1.

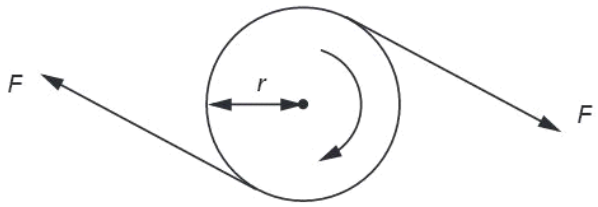


Fig. 5.1

(a) The disc is made to complete n revolutions about an axis through its centre, normal to the plane of the disc. Write down an expression for

(i) the distance moved by a point on the circumference of the disc,

distance = ...

(ii) the work done by one of the two forces.

work done = ...
[2]

(b) Using your answer to **(a)**, show that the work W done by a couple producing a torque T when it turns through n revolutions is given by

$$W = 2\pi nT.$$ [2]

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(c) A car engine produces a torque of 470 N m at 2400 revolutions per minute. Calculate the output power of the engine.

power = ... W [2]

Q4.

3 A bullet of mass 2.0 g is fired horizontally into a block of wood of mass 600 g. The block is suspended from strings so that it is free to move in a vertical plane.
The bullet buries itself in the block. The block and bullet rise together through a vertical distance of 8.6 cm, as shown in Fig. 3.1.

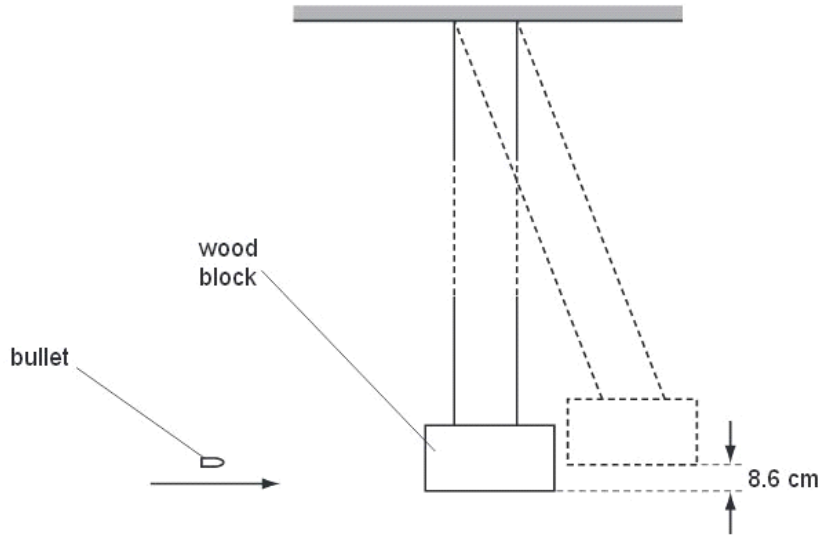


Fig. 3.1

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(a) (i) Calculate the change in gravitational potential energy of the block and bullet.

change = ... J [2]

(ii) Show that the initial speed of the block and the bullet, after they began to move off together, was 1.3 m s^{-1}.

[1]

(b) Using the information in **(a)(ii)** and the principle of conservation of momentum, determine the speed of the bullet before the impact with the block.

Ex

speed = ... m s^{-1} [2]

(c) (i) Calculate the kinetic energy of the bullet just before impact.

kinetic energy = ... J [2]

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(ii) State and explain what can be deduced from your answers to **(c)(i)** and **(a)(i)** about the type of collision between the bullet and the block.

.....

.....

.....[2]

Q5.

Use

2 A rod AB is hinged to a wall at A. The rod is held horizontally by means of a cord BD, attached to the rod at end B and to the wall at D, as shown in Fig. 2.1.

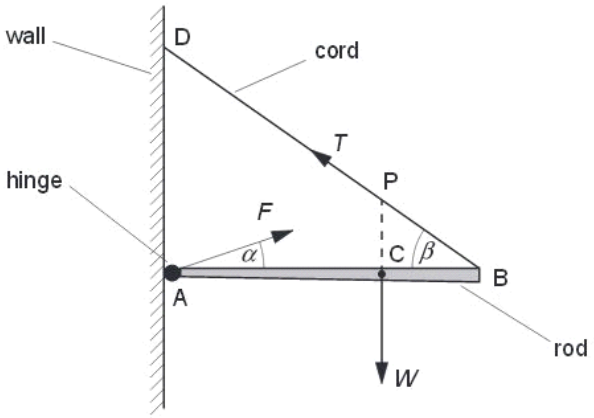


Fig. 2.1

The rod has weight *W* and the centre of gravity of the rod is at C. The rod is held in equilibrium by a force *T* in the cord and a force *F* produced at the hinge.

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(a) Explain what is meant by

(i) the *centre of gravity* of a body,

.....

.....

..... [2]

(ii) the *equilibrium* of a body.

.....

.....

.....

..... [2]

(b) The line of action of the weight *W* of the rod passes through the cord at point P.

Explain why, for the rod to be in equilibrium, the force *F* produced at the hinge must also pass through point P.

.....

.....

.....

..... [2]

(c) The forces *F* and *T* make angles α and β respectively with the rod and AC = $\frac{1}{3}$AB, as shown in Fig. 2.1.

Write down equations, in terms of *F*, *W*, *T*, α and β, to represent

(i) the resolution of forces horizontally,

..... [1]

(ii) the resolution of forces vertically,

..... [1]

(iii) the taking of moments about A.

..... [1]

Q6.

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3 A shopping trolley and its contents have a total mass of 42 kg. The trolley is being pushed along a horizontal surface at a speed of $1.2\,m\,s^{-1}$. When the trolley is released, it travels a distance of 1.9 m before coming to rest.

For Examin Use

(a) Assuming that the total force opposing the motion of the trolley is constant,

(i) calculate the deceleration of the trolley,

deceleration = ... $m\,s^{-2}$ [2]

(ii) show that the total force opposing the motion of the trolley is 16 N.

[1]

(b) Using the answer in **(a)(ii)**, calculate the power required to overcome the total force opposing the motion of the trolley at a speed of $1.2\,m\,s^{-1}$.

power = ... W [2]

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(c) The trolley now moves down a straight slope that is inclined at an angle of 2.8° to the horizontal, as shown in Fig. 3.1.

For Examiner's Use

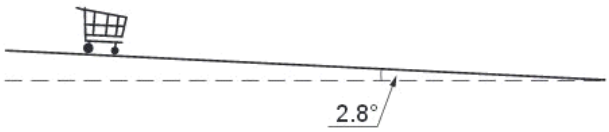


Fig. 3.1

The constant force that opposes the motion of the trolley is 16 N.

Calculate, for the trolley moving down the slope,

(i) the component down the slope of the trolley's weight,

component of weight = ... N [2]

(ii) the time for the trolley to travel from rest a distance of 3.5 m along the length of the slope.

time = ... s [4]

(d) Use your answer to **(c)(ii)** to explain why, for safety reasons, the slope is not made any steeper.

.....

.....[1]

Q7.

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2 A spring is placed on a flat surface and different weights are placed on it, as shown in Fig. 2.1.

For Examiner's Use

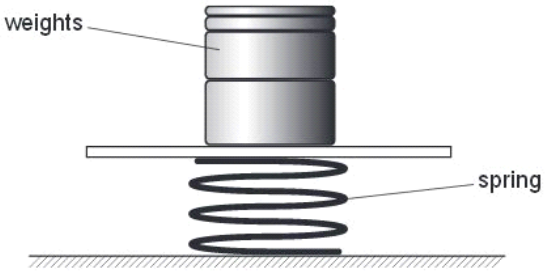


Fig. 2.1

The variation with weight of the compression of the spring is shown in Fig. 2.2.

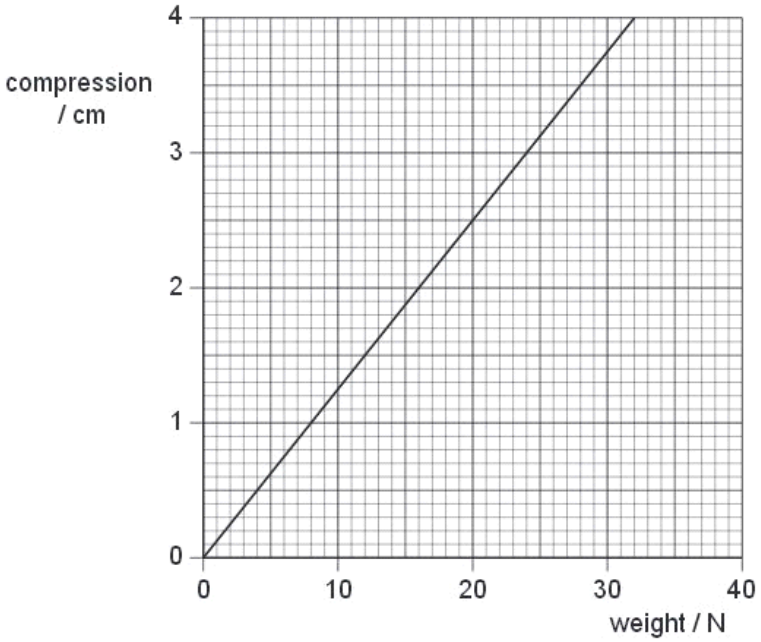


Fig. 2.2

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The elastic limit of the spring has not been exceeded.

(a) (i) Determine the spring constant k of the spring.

k = ... Nm^{-1} [2]

(ii) Deduce that the strain energy stored in the spring is 0.49 J for a compression of 3.5 cm.

[2]

(b) Two trolleys, of masses 800 g and 2400 g, are free to move on a horizontal table. The spring in **(a)** is placed between the trolleys and the trolleys are tied together using thread so that the compression of the spring is 3.5 cm, as shown in Fig. 2.3.

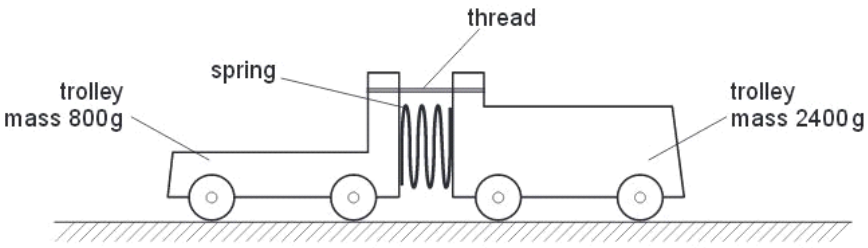


Fig. 2.3

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Initially, the trolleys are not moving.
The thread is then cut and the trolleys move apart.

(i) Deduce that the ratio

$$\frac{\text{speed of trolley of mass 800 g}}{\text{speed of trolley of mass 2400 g}}$$

is equal to 3.0.

[2]

(ii) Use the answers in **(a)(ii)** and **(b)(i)** to calculate the speed of the trolley of mass 800 g.

For Examiner Use

speed = ... $m\,s^{-1}$ [3]

Q8.

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2 A ball B of mass 1.2 kg travelling at constant velocity collides head-on with a stationary ball S of mass 3.6 kg, as shown in Fig. 2.1.

For Examiner's Use



Fig. 2.1

Frictional forces are negligible.

The variation with time t of the velocity v of ball B before, during and after colliding with ball S is shown in Fig. 2.2.

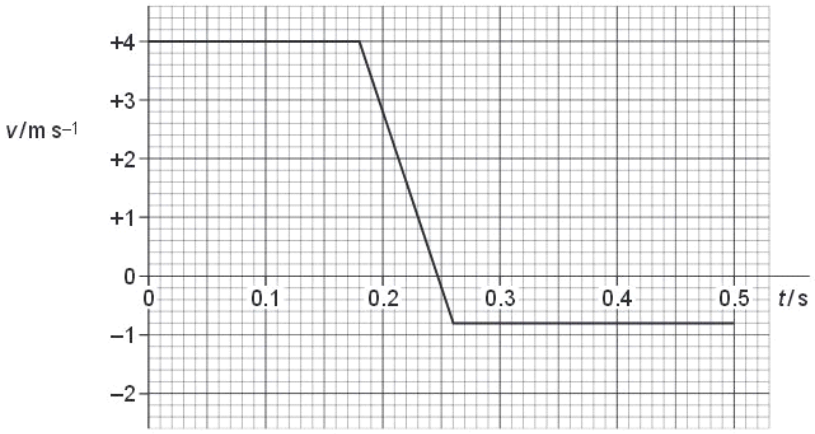


Fig. 2.2

(a) State the significance of positive and negative values for v in Fig. 2.2.

.....

..... [1]

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(b) Use Fig. 2.2 to determine, for ball B during the collision with ball S,

(i) the change in momentum of ball B,

change in momentum = ... Ns [3]

(ii) the magnitude of the force acting on ball B.

force = ... N [3]

(c) Calculate the speed of ball S after the collision.

speed = ... $m\,s^{-1}$ [2]

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(d) Using your answer in **(c)** and information from Fig. 2.2, deduce quantitatively whether the collision is elastic or inelastic.

For Exam U

.....

..... [2]

Q9.

3 **(a)** Define the *torque* of a couple.

For Examiner's Use

.....

.....

..... [2]

(b) A torque wrench is a type of spanner for tightening a nut and bolt to a particular torque, as illustrated in Fig. 3.1.

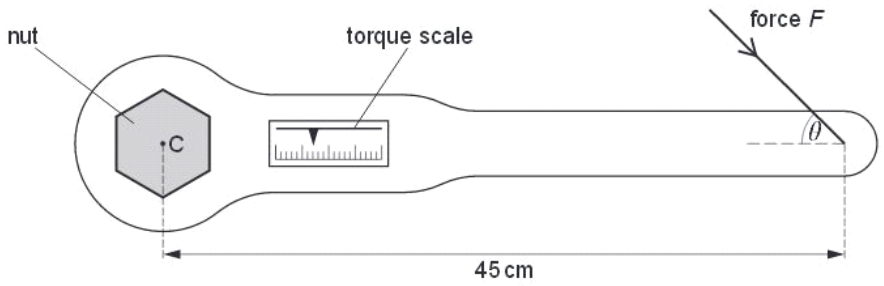


Fig. 3.1

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The wrench is put on the nut and a force is applied to the handle. A scale indicates the torque applied.

The wheel nuts on a particular car must be tightened to a torque of 130 Nm. This is achieved by applying a force F to the wrench at a distance of 45 cm from its centre of rotation C. This force F may be applied at any angle θ to the axis of the handle, as shown in Fig. 3.1.

For the minimum value of F to achieve this torque,

(i) state the magnitude of the angle θ that should be used,

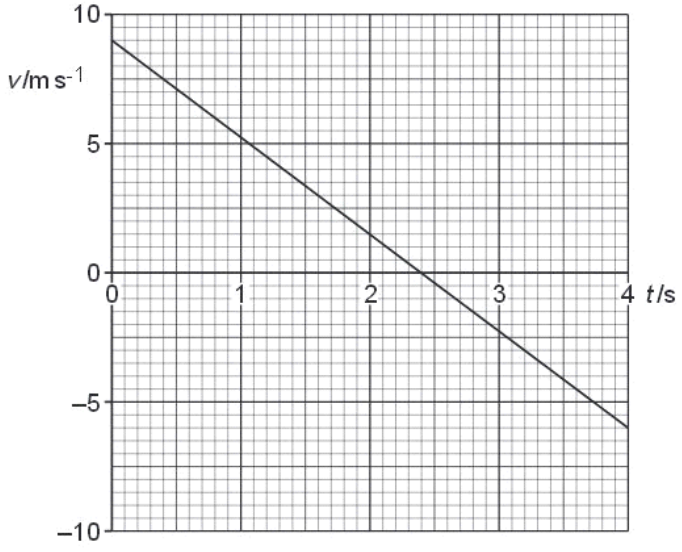
θ = ... ° [1]

(ii) calculate the magnitude of F.

F = ... N [2]

Q10.

2 An experiment is conducted on the surface of the planet Mars.
A sphere of mass 0.78 kg is projected almost vertically upwards from the surface of the planet. The variation with time t of the vertical velocity v in the upward direction is shown in Fig. 2.1.



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The sphere lands on a small hill at time $t = 4.0\,s$.

(a) State the time t at which the sphere reaches its maximum height above the planet's surface.

t = ... s [1]

(b) Determine the vertical height above the point of projection at which the sphere finally comes to rest on the hill.

height = ...m [3]

(c) Calculate, for the first 3.5 s of the motion of the sphere,

(i) the change in momentum of the sphere,

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

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(ii) the force acting on the sphere.

force = ...N [2]

(d) Using your answer in **(c)(ii)**,

(i) state the weight of the sphere,

weight = ...N [1]

(ii) determine the acceleration of free fall on the surface of Mars.

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

Q11.

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3 **(a)** The variation with extension x of the tension F in a spring is shown in Fig. 3.1.

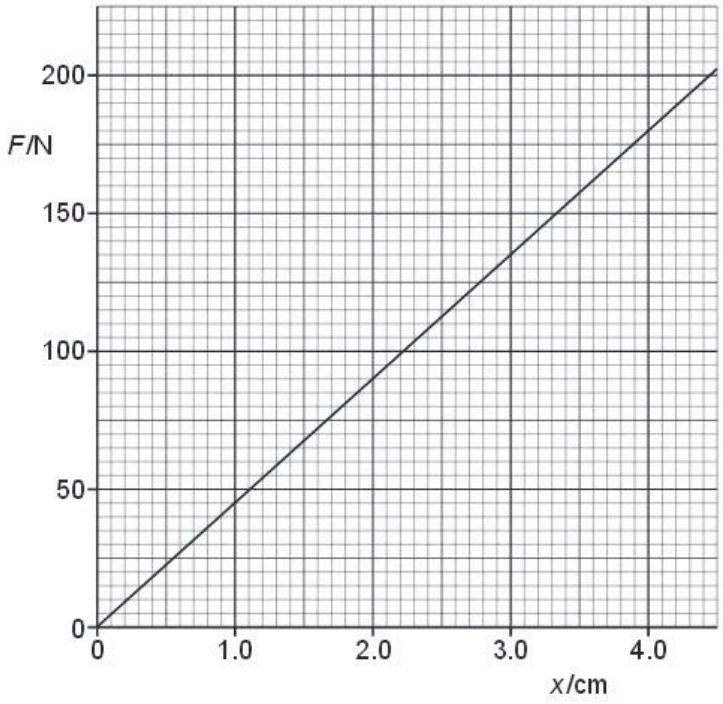


Fig. 3.1

Use Fig. 3.1 to calculate the energy stored in the spring for an extension of 4.0 cm.
Explain your working.

energy = ... J [3]

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(b) The spring in **(a)** is used to join together two frictionless trolleys A and B of mass M_1 and M_2 respectively, as shown in Fig. 3.2.

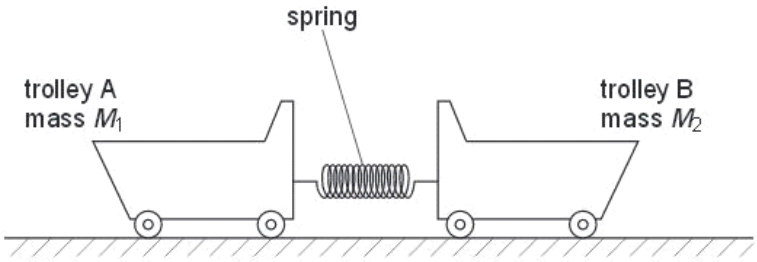


Fig. 3.2

The trolleys rest on a horizontal surface and are held apart so that the spring is extended.

The trolleys are then released.

(i) Explain why, as the extension of the spring is reduced, the momentum of trolley A is equal in magnitude but opposite in direction to the momentum of trolley B.

.....

.....

.....

.....[2]

(ii) At the instant when the extension of the spring is zero, trolley A has speed V_1 and trolley B has speed V_2.
Write down

1. an equation, based on momentum, to relate V_1 and V_2,

.....

.....[1]

2. an equation to relate the initial energy E stored in the spring to the final energies of the trolleys.

.....

.....[1]

Q12.

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3 **(a)** **(i)** Define *force*.

.....

.....[1]

(ii) State Newton's third law of motion.

.....

.....

.....

.....[3]

(b) Two spheres approach one another along a line joining their centres, as illustrated in Fig. 3.1.

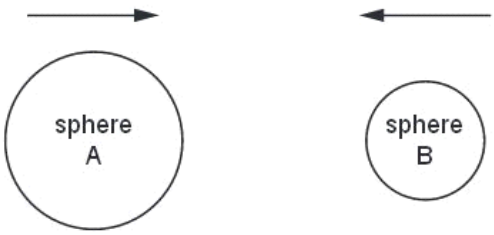


Fig. 3.1

When they collide, the average force acting on sphere A is F_A and the average force acting on sphere B is F_B.

The forces act for time t_A on sphere A and time t_B on sphere B.

(i) State the relationship between

1. F_A and F_B,

.....[1]

2. t_A and t_B.

.....[1]

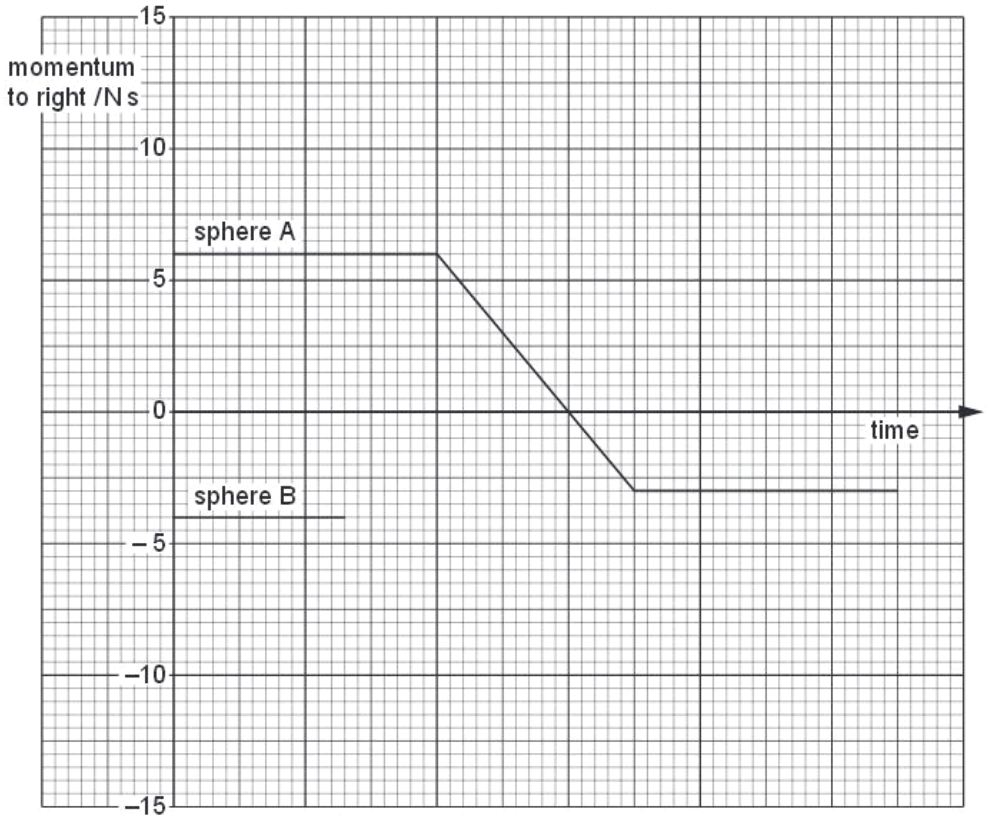
(ii) Use your answers in **(i)** to show that the change in momentum of sphere A is equal in magnitude and opposite in direction to the change in momentum of sphere B.

.....

.....[1]

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(c) For the spheres in **(b)**, the variation with time of the momentum of sphere A before, during and after the collision with sphere B is shown in Fig. 3.2.



The momentum of sphere B before the collision is also shown on Fig. 3.2.

Complete Fig. 3.2 to show the variation with time of the momentum of sphere B during and after the collision with sphere A. [3]

Q13.

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2 **(a)** State the two conditions that must be satisfied for a body to be in equilibrium.

For Examine Use

1. .....

.....

2. .....

.....

[2]

(b) Three co-planar forces act on a body that is in equilibrium.

(i) Describe how to draw a vector triangle to represent these forces.

.....

.....

.....

.....

.....

.....

.....[3]

(ii) State how the triangle confirms that the forces are in equilibrium.

.....

.....[1]

(c) A weight of 7.0 N hangs vertically by two strings AB and AC, as shown in Fig. 2.1.

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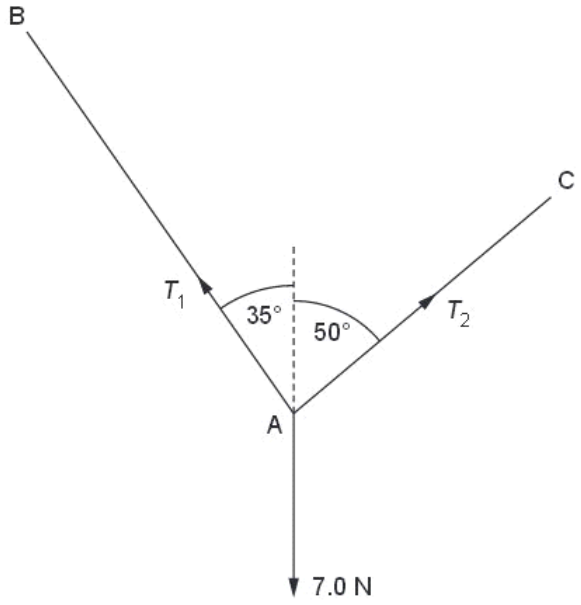


Fig. 2.1

For the weight to be in equilibrium, the tension in string AB is T_1 and in string AC it is T_2.

On Fig. 2.1, draw a vector triangle to determine the magnitudes of T_1 and T_2.

T_1 = ... N

T_2 = ... N

[3]

(d) By reference to Fig. 2.1, suggest why the weight could not be supported with the strings AB and AC both horizontal.

.....

.....[2]

Q14.

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3 **(a)** Explain what is meant by *centre of gravity*.

.....

..... [2]

(b) Define *moment* of a force.

.....

..... [1]

(c) A student is being weighed. The student, of weight *W*, stands 0.30 m from end A of a uniform plank AB, as shown in Fig. 3.1.

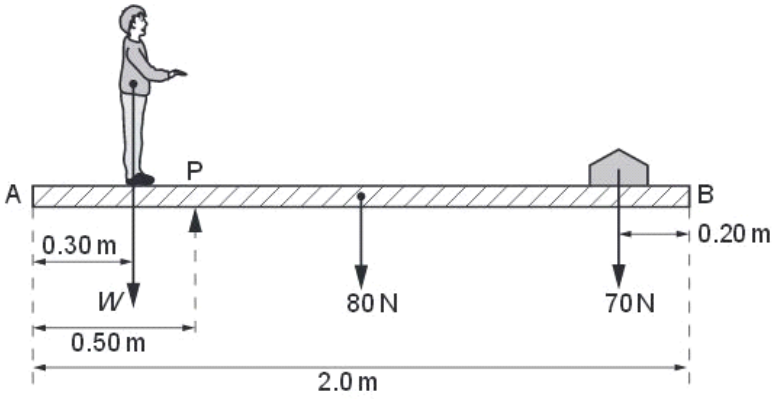


Fig. 3.1 (not to scale)

The plank has weight 80 N and length 2.0 m. A pivot P supports the plank and is 0.50 m from end A.
A weight of 70 N is moved to balance the weight of the student. The plank is in equilibrium when the weight is 0.20 m from end B.

(i) State the two conditions necessary for the plank to be in equilibrium.

1. .....

.....

2. .....

.....

[2]

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(ii) Determine the weight W of the student.

W = ... N [3]

(iii) If only the 70 N weight is moved, there is a maximum weight of student that can be determined using the arrangement shown in Fig. 3.1. State and explain **one** change that can be made to increase this maximum weight.

.....

.....

..... [2]

Q15.

2 A climber is supported by a rope on a vertical wall, as shown in Fig. 2.1.

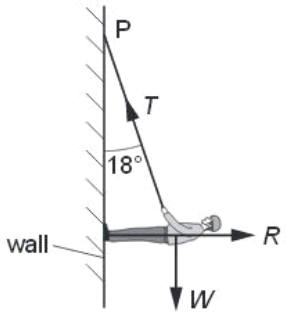


Fig. 2.1

The weight W of the climber is 520 N. The rope, of negligible weight, is attached to the climber and to a fixed point P where it makes an angle of 18° to the vertical. The reaction force R acts at right-angles to the wall.
The climber is in equilibrium.

(a) State the conditions necessary for the climber to be in equilibrium.

.....

.....

.....[2]

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(b) Complete Fig. 2.2 by drawing a labelled vector triangle to represent the forces acting on the climber.



Fig. 2.2

[2]

(c) Resolve forces or use your vector triangle to calculate

(i) the tension T in the rope,

T = ... N [2]

(ii) the reaction force R.

R = ... N [1]

(d) The climber moves up the wall and the angle the rope makes with the vertical increases. Explain why the magnitude of the tension in the rope increases.

.....

.....

.....[1]

Q16.

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3 A helicopter has a cable hanging from it towards the sea below, as shown in Fig. 3.1.

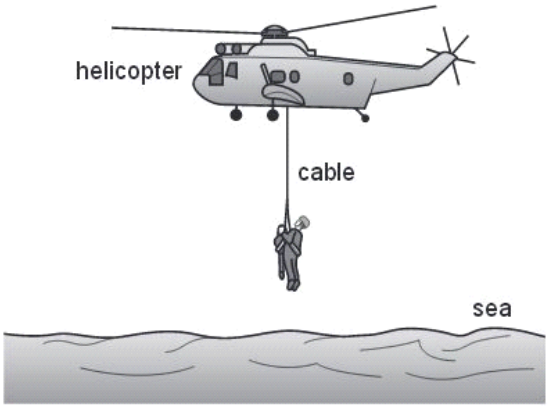


Fig. 3.1

A man of mass 80 kg rescues a child of mass 50.5 kg. The two are attached to the cable and are lifted from the sea to the helicopter. The lifting process consists of an initial uniform acceleration followed by a period of constant velocity and then completed by a final uniform deceleration.

(a) Calculate the combined weight of the man and child.

weight = ... N [1]

(b) Calculate the tension in the cable during

(i) the initial acceleration of 0.570 m s^{-2},

tension = ... N [2]

(ii) the period of constant velocity of 2.00 m s^{-1}.

tension = ... N [1]

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(c) During the final deceleration the tension in the cable is 1240N. Calculate this deceleration.

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deceleration = ... $m\,s^{-2}$ [2]

(d) **(i)** Calculate the time over which the man and child are

1. moving with uniform acceleration,

time = ... s [1]

2. moving with uniform deceleration.

time = ... s [1]

(ii) The time over which the man and child are moving with constant velocity is 20s. On Fig. 3.2, sketch a graph to show the variation with time of the velocity of the man and child for the complete lifting process.

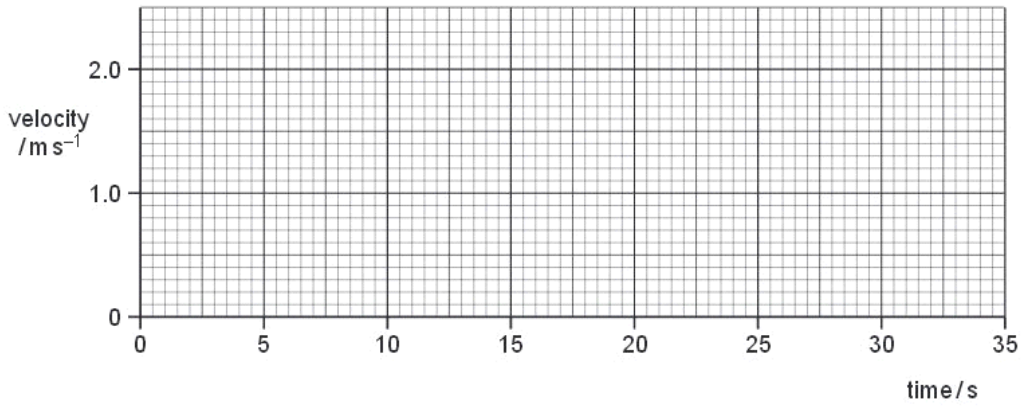


Fig. 3.2

[2]

Q17.

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2 A ball is thrown vertically down towards the ground with an initial velocity of $4.23\,m\,s^{-1}$. The ball falls for a time of 1.51 s before hitting the ground. Air resistance is negligible.

Ex

(a) (i) Show that the downwards velocity of the ball when it hits the ground is $19.0\,m\,s^{-1}$.

[2]

(ii) Calculate, to three significant figures, the distance the ball falls to the ground.

distance = ... m [2]

(b) The ball makes contact with the ground for 12.5 ms and rebounds with an upwards velocity of $18.6\,m\,s^{-1}$. The mass of the ball is 46.5 g.

(i) Calculate the average force acting on the ball on impact with the ground.

magnitude of force = ... N

direction of force .....

[4]

(ii) Use conservation of energy to determine the maximum height the ball reaches after it hits the ground.

height = ... m [2]

(c) State and explain whether the collision the ball makes with the ground is elastic or inelastic.

.....

.....

.....[1]

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Q18.

3 **(a)** State Newton's first law.

.....

.....[1]

(b) A log of mass 450 kg is pulled up a slope by a wire attached to a motor, as shown in Fig. 3.1.

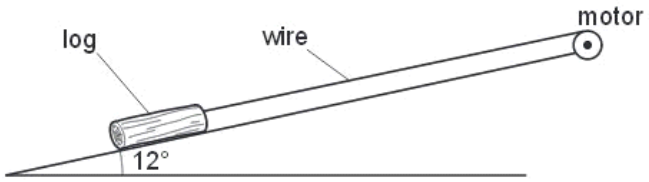


Fig. 3.1

The angle that the slope makes with the horizontal is 12°. The frictional force acting on the log is 650 N. The log travels with constant velocity.

(i) With reference to the motion of the log, discuss whether the log is in equilibrium.

.....

.....

.....

.....[2]

(ii) Calculate the tension in the wire.

tension = ... N [3]

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(iii) State and explain whether the gain in the potential energy per unit time of the log is equal to the output power of the motor.

.....

.....

.....

.....[2]

Q19.

1 **(a)** Explain the differences between the quantities *distance* and *displacement.*

.....

.....

.....[2]

(b) State Newton's first law.

.....

.....

.....[1]

(c) Two tugs pull a tanker at constant velocity in the direction XY, as represented in Fig. 1.1.

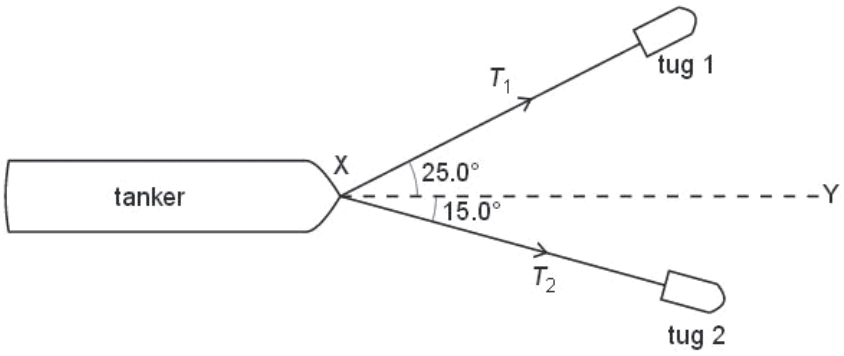


Fig. 1.1

Tug 1 pulls the tanker with a force T_1 at 25.0° to XY. Tug 2 pulls the tanker with a force of T_2 at 15.0° to XY. The resultant force R due to the two tugs is 25.0×10^3 N in the direction XY.

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(i) By reference to the forces acting on the tanker, explain how the tanker may be described as being in equilibrium.

.....

.....

.....

.....[2]

(ii) **1.** Complete Fig. 1.2 to draw a vector triangle for the forces R, T_1 and T_2. [2]

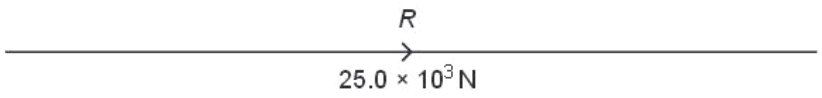


Fig. 1.2

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2. Use your vector triangle in Fig. 1.2 to determine the magnitude of T_1 and of T_2.

T_1 = ... N

T_2 = ... N
[2]

Q20.

2 A motor drags a log of mass 452 kg up a slope by means of a cable, as shown in Fig. 2.1.

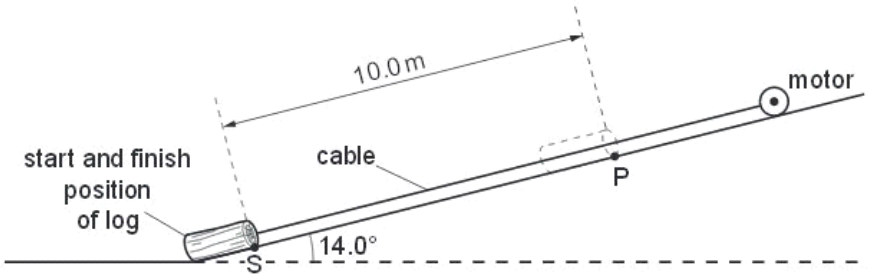


Fig. 2.1

The slope is inclined at 14.0° to the horizontal.

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(a) Show that the component of the weight of the log acting down the slope is 1070 N.

[1]

(b) The log starts from rest. A constant frictional force of 525 N acts on the log. The log accelerates up the slope at 0.130 m s^{-2}.

(i) Calculate the tension in the cable.

tension = ... N [3]

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(ii) The log is initially at rest at point S. It is pulled through a distance of 10.0 m to point P.

Calculate, for the log,

1. the time taken to move from S to P,

time = ... s [2]

2. the magnitude of the velocity at P.

velocity = ... $m\,s^{-1}$ [1]

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(c) The cable breaks when the log reaches point P. On Fig. 2.2, sketch the variation with time *t* of the velocity *v* of the log. The graph should show *v* from the start at S until the log returns to S. **[4]**



Fig. 2.2

Q21.

2 **(a)** Distinguish between *mass and weight*.

mass: .....

.....

weight: .....

.....

[2]

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(b) An object O of mass 4.9 kg is suspended by a rope A that is fixed at point P. The object is pulled to one side and held in equilibrium by a second rope B, as shown in Fig. 2.1.

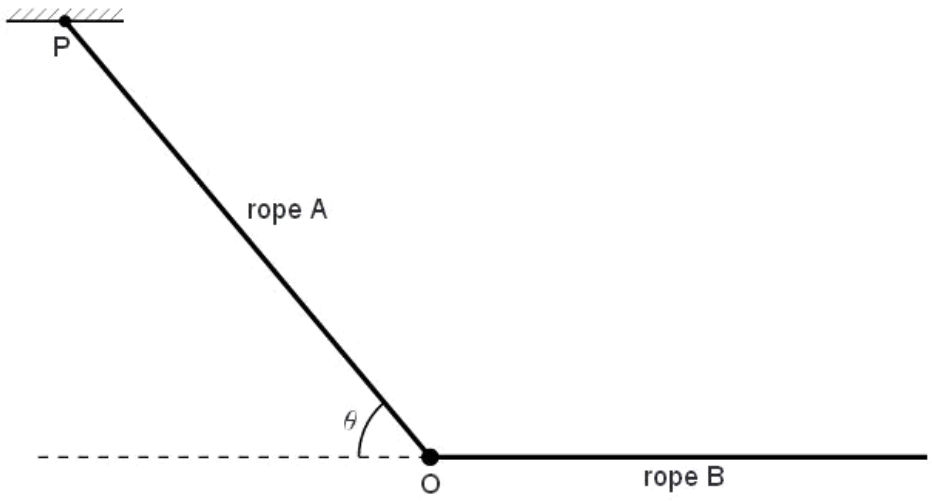


Fig. 2.1

Rope A is at an angle θ to the horizontal and rope B is horizontal. The tension in rope A is 69 N and the tension in rope B is T.

(i) On Fig. 2.1, draw arrows to represent the directions of all the forces acting on object O. [2]

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(ii) Calculate

1. the angle θ,

θ = ...° [3]

2. the tension T.

T = ... N [2]

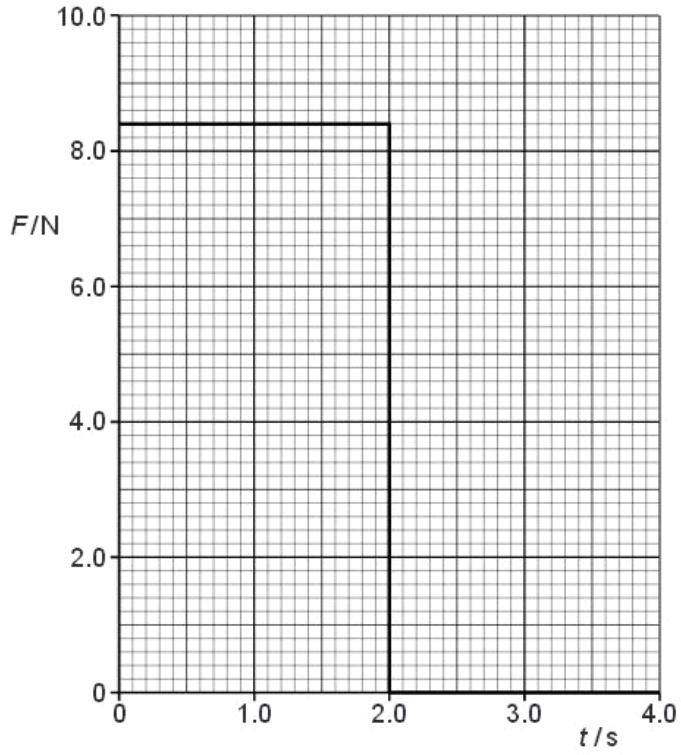
Q22.

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2 **(a)** Define *force*.

..... [1]

(b) A resultant force F acts on an object of mass 2.4 kg. The variation with time t of F is shown in Fig. 2.1.



The object starts from rest.

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(i) On Fig. 2.2, show quantitatively the variation with t of the acceleration a of the object. Include appropriate values on the y-axis.

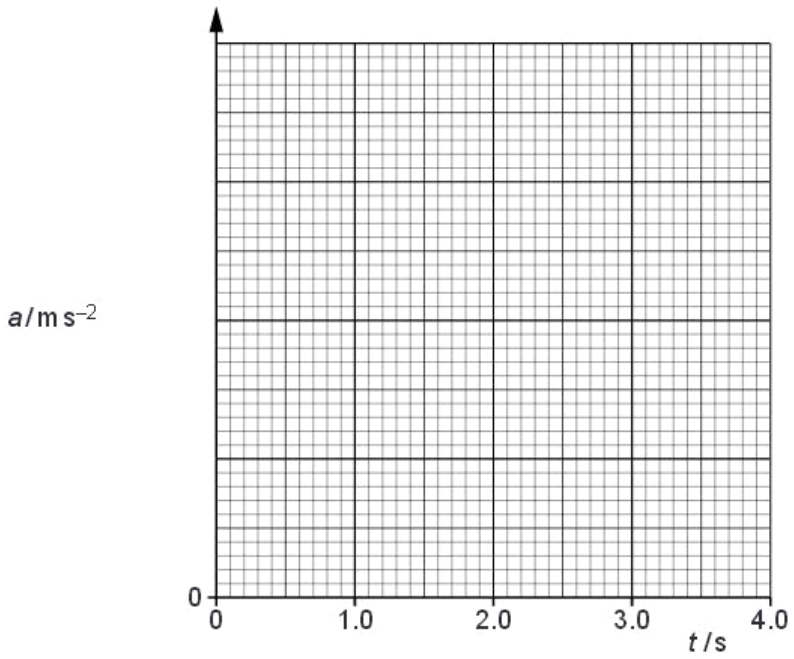


Fig. 2.2

[4]

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(ii) On Fig. 2.3, show quantitatively the variation with t of the momentum p of the object. Include appropriate values on the y-axis.

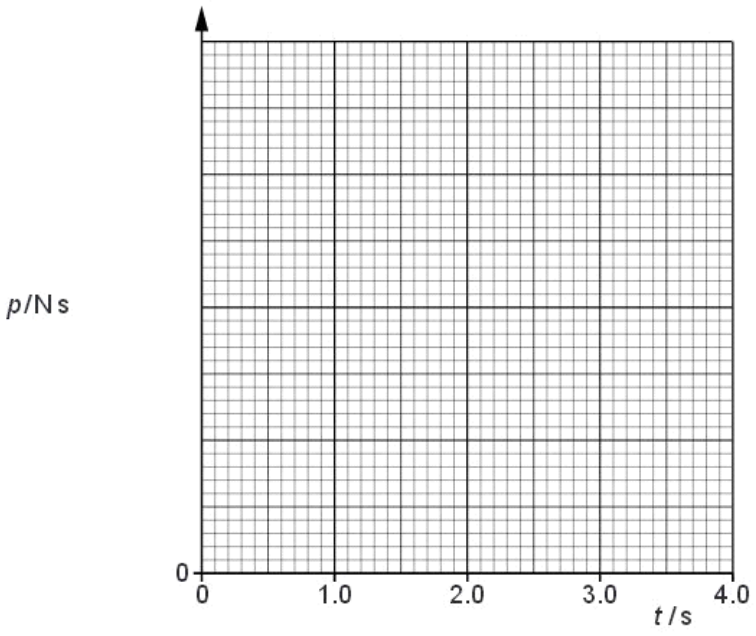


Fig. 2.3

[5]

Q23.

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3 **(a)** Define *centre of gravity*.

.....

.....[2]

(b) A uniform rod AB is attached to a vertical wall at A. The rod is held horizontally by a string attached at B and to point C, as shown in Fig. 3.1.

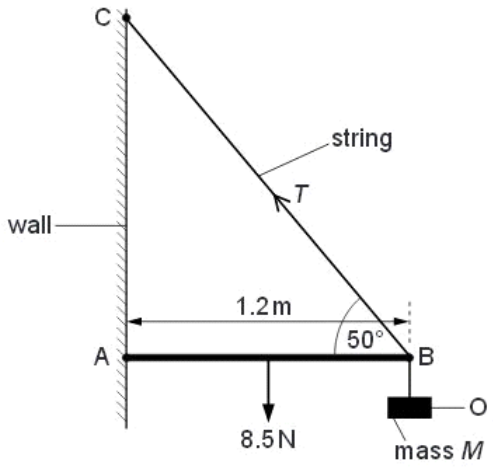


Fig. 3.1

The angle between the rod and the string at B is 50°. The rod has length 1.2 m and weight 8.5 N. An object O of mass *M* is hung from the rod at B. The tension *T* in the string is 30 N.

(i) Use the resolution of forces to calculate the vertical component of *T*.

vertical component of *T* = ... N [1]

(ii) State the *principle of moments*.

.....

.....[1]

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(iii) Use the principle of moments and take moments about A to show that the weight of the object O is 19 N.

[3]

(iv) Hence determine the mass *M* of the object O.

M = ... kg [1]

(c) Use the concept of equilibrium to explain why a force must act on the rod at A.

.....

.....

.....[2]

Q24.

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3 **(a)** **(i)** State the principle of conservation of momentum.

.....

.....

.....[2]

(ii) State the difference between an elastic and an inelastic collision.

.....[1]

(b) An object A of mass 4.2 kg and horizontal velocity 3.6 m s^{-1} moves towards object B as shown in Fig. 3.1.

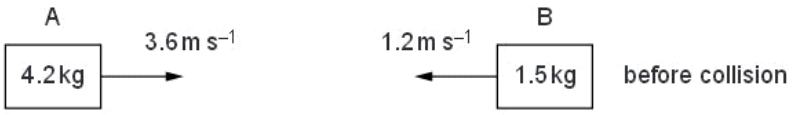


Fig. 3.1

Object B of mass 1.5 kg is moving with a horizontal velocity of 1.2 m s^{-1} towards object A.

The objects collide and then both move to the right, as shown in Fig. 3.2.



Fig. 3.2

Object A has velocity v and object B has velocity 3.0 m s^{-1}.

(i) Calculate the velocity v of object A after the collision.

velocity = ... m s^{-1} [3]

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(ii) Determine whether the collision is elastic or inelastic.

[3]

Q25.

Use

2 **(a)** Distinguish between the mass of a body and its weight.

mass .....

.....

weight .....

..... [3]

(b) State two situations where a body of constant mass may experience a change in its apparent weight.

1. .....

.....

2. .....

..... [2]

Q26.

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

.....

..... [2]

(b) State the two conditions necessary for a body to be in equilibrium.

1. .....

.....

2. .....

..... [2]

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(c) Two parallel strings S_1 and S_2 are attached to a disc of diameter 12 cm, as shown in Fig. 3.1.

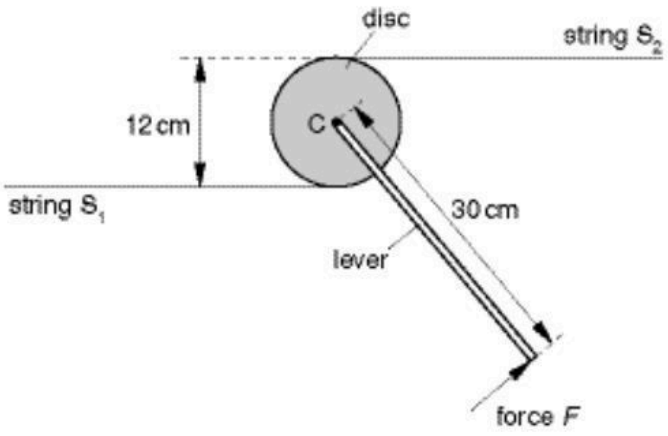


Fig. 3.1

The disc is free to rotate about an axis normal to its plane. The axis passes through the centre C of the disc.

A lever of length 30 cm is attached to the disc. When a force F is applied at right angles to the lever at its end, equal forces are produced in S_1 and S_2. The disc remains in equilibrium.

(i) On Fig. 3.1, show the direction of the force in each string that acts on the disc. [1]

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(ii) For a force F of magnitude 150N, determine

1. the moment of force F about the centre of the disc,

moment = ... N m

2. the torque of the couple produced by the forces in the strings,

torque = ... N m

3. the force in S_1.

force = ... N

[4]

Q27.

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2 **(a)** Explain what is meant by the *centre of gravity* of a body.

.....

.....

..... [2]

(b) An irregularly-shaped piece of cardboard is hung freely from one point near its edge, as shown in Fig. 2.1.

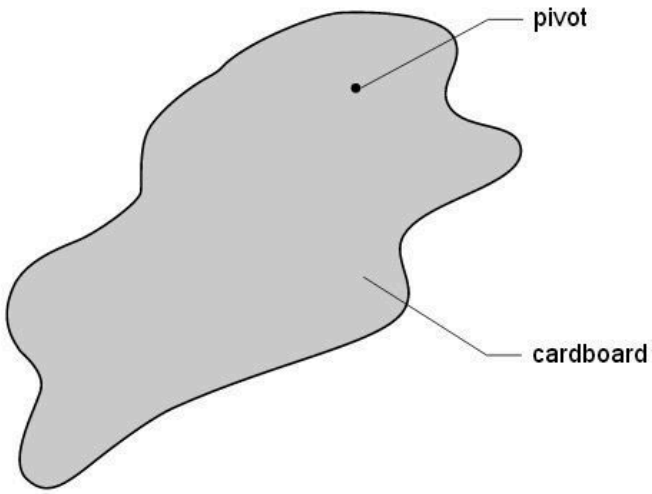


Fig. 2.1

Explain why the cardboard will come to rest with its centre of gravity vertically below the pivot. You may draw on Fig. 2.1 if you wish.

.....

.....

..... [2]

Q28.

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3 A stone on a string is made to travel along a horizontal circular path, as shown in Fig. 3.1.

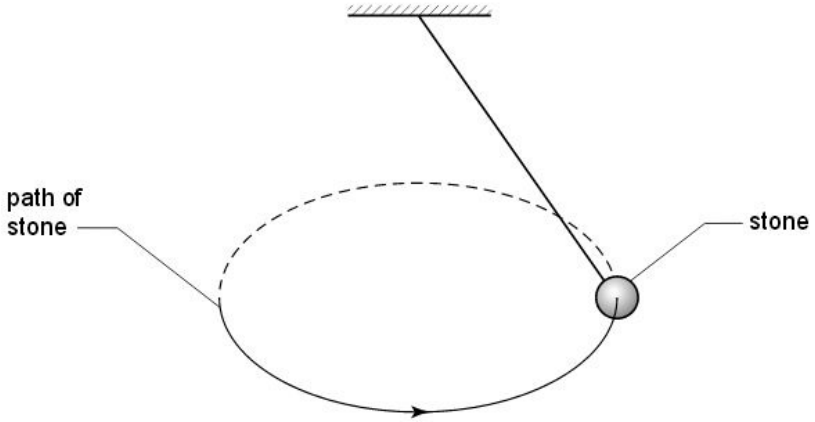


Fig. 3.1

The stone has a constant speed.

(a) Define *acceleration*.

.....

..... [1]

(b) Use your definition to explain whether the stone is accelerating.

.....

.....

..... [2]

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(c) The stone has a weight of 5.0 N. When the string makes an angle of 35° to the vertical, the tension in the string is 6.1 N, as illustrated in Fig. 3.2.

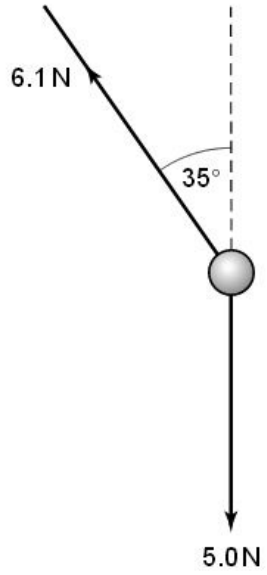


Fig. 3.2

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Determine the resultant force acting on the stone in the position shown.

magnitude of force = ... N

direction of force..... [4]

Q29.

4 A trolley of mass 930 g is held on a horizontal surface by means of two springs, as shown in Fig. 4.1.

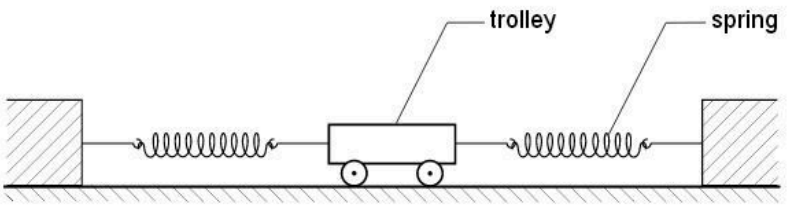


Fig. 4.1

The variation with time *t* of the speed *v* of the trolley for the first 0.60 s of its motion is shown in Fig. 4.2.

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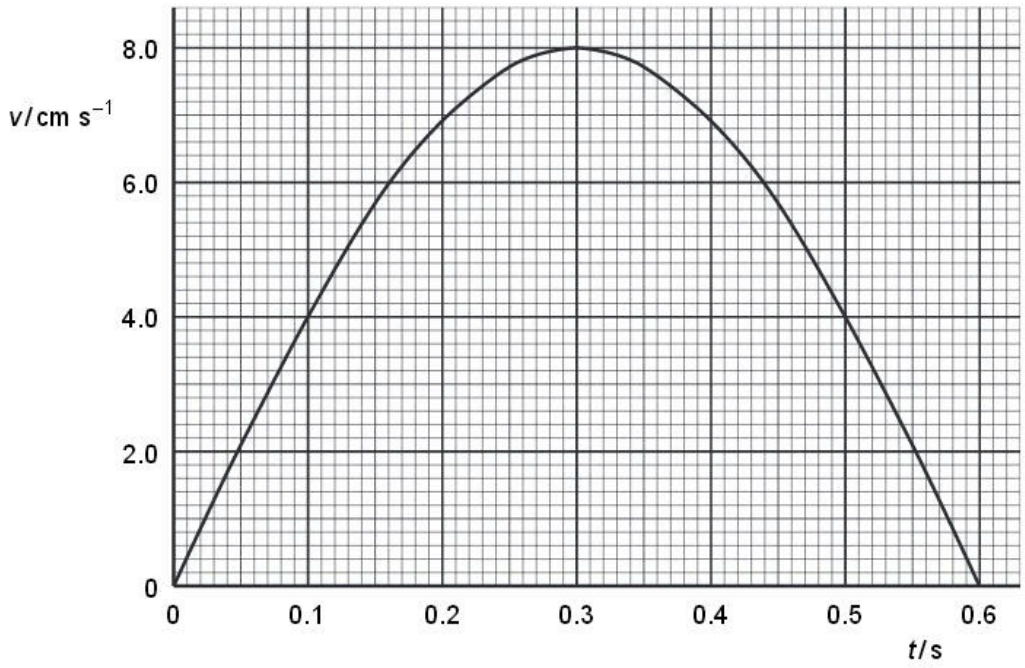


Fig. 4.2

(a) Use Fig. 4.2 to determine

(i) the initial acceleration of the trolley,

acceleration = ... m s^{-2} [2]

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(ii) the distance moved during the first 0.60 s of its motion.

distance = ... m [3]

(b) **(i)** Use your answer to **(a)(i)** to determine the resultant force acting on the trolley at time $t = 0$.

force = ... N [2]

(ii) Describe qualitatively the variation with time of the resultant force acting on the trolley during the first 0.60 s of its motion.

.....

.....

.....

..... [3]

Q30.

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3 Francium-208 is radioactive and emits α-particles with a kinetic energy of 1.07×10^{-12} J to form nuclei of astatine, as illustrated in Fig. 3.1.

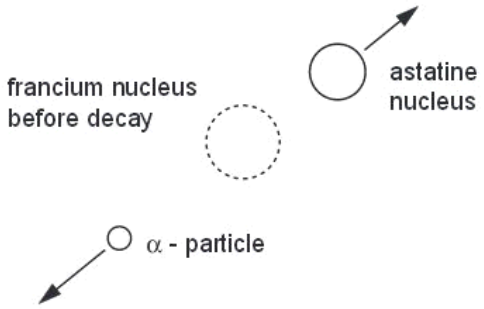


Fig. 3.1

(a) State the nature of an α-particle.

.....

..... [1]

(b) Show that the initial speed of an α-particle after the decay of a francium nucleus is approximately 1.8×10^{7} m s^{-1}.

[2]

(c) (i) State the principle of conservation of linear momentum.

.....

.....

..... [2]

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(ii) The Francium-208 nucleus is stationary before the decay. Estimate the speed of the astatine nucleus immediately after the decay.

For Examiner's Use

speed = ... m s^{-1} [3]

(d) Close examination of the decay of the francium nucleus indicates that the astatine nucleus and the α-particle are not ejected exactly in opposite directions.

Suggest an explanation for this observation.

.....

.....

..... [2]

Q31.

3 **(a)** Distinguish between the moment of a force and the torque of a couple.

Ex

moment of a force .....

.....

.....

torque of a couple .....

.....

.....

[4]

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(b) One type of weighing machine, known as a steelyard, is illustrated in Fig. 3.1.

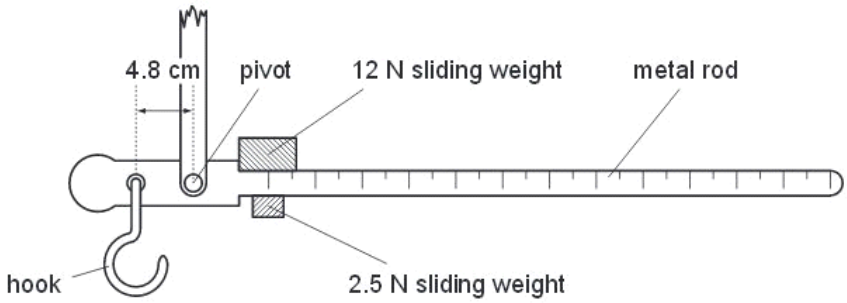


Fig. 3.1

The two sliding weights can be moved independently along the rod.

With no load on the hook and the sliding weights at the zero mark on the metal rod, the metal rod is horizontal. The hook is 4.8 cm from the pivot.

A sack of flour is suspended from the hook. In order to return the metal rod to the horizontal position, the 12 N sliding weight is moved 84 cm along the rod and the 2.5 N weight is moved 72 cm.

(i) Calculate the weight of the sack of flour.

weight = ...N [2]

(ii) Suggest why this steelyard would be imprecise when weighing objects with a weight of about 25 N.

.....

.....[1]

Q32.

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3 A stationary nucleus of mass 220u undergoes radioactive decay to produce a nucleus D of mass 216u and an α-particle of mass 4u, as illustrated in Fig. 3.1.

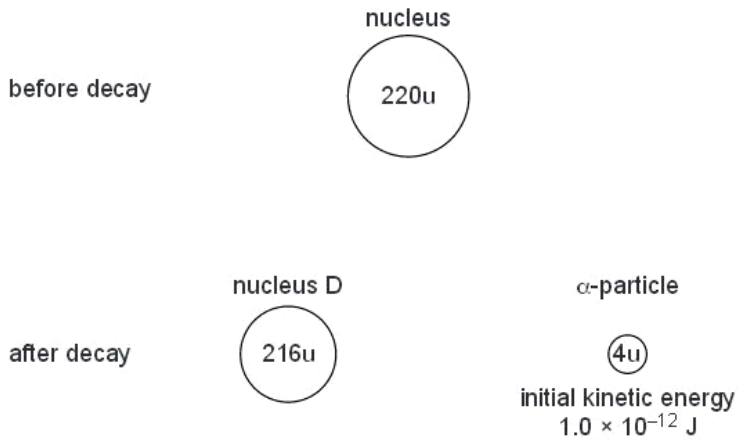


Fig. 3.1

The initial kinetic energy of the α-particle is 1.0×10^{-12} J.

(a) (i) State the law of conservation of linear momentum.

.....

.....

..... [2]

(ii) Explain why the initial velocities of the nucleus D and the α-particle must be in opposite directions.

.....

.....

..... [2]

(b) (i) Show that the initial speed of the α-particle is $1.7 \times 10^{7}\,\text{m s}^{-1}$.

[2]

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(ii) Calculate the initial speed of nucleus D.

speed = ... $m\,s^{-1}$ [2]

(c) The range in air of the emitted α-particle is 4.5 cm.
Calculate the average deceleration of the α-particle as it is stopped by the air.

deceleration = ... $m\,s^{-2}$ [2]

Q33.

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3 **(a)** State the relation between force and momentum.

For Examine Use

..... [1]

(b) A rigid bar of mass 450 g is held horizontally by two supports A and B, as shown in Fig. 3.1.

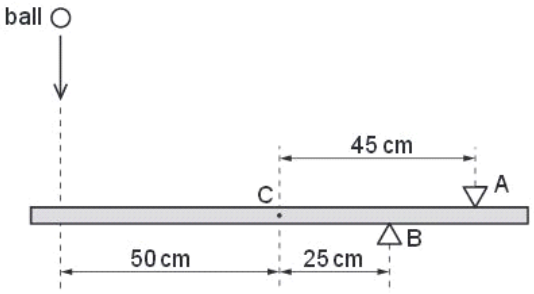
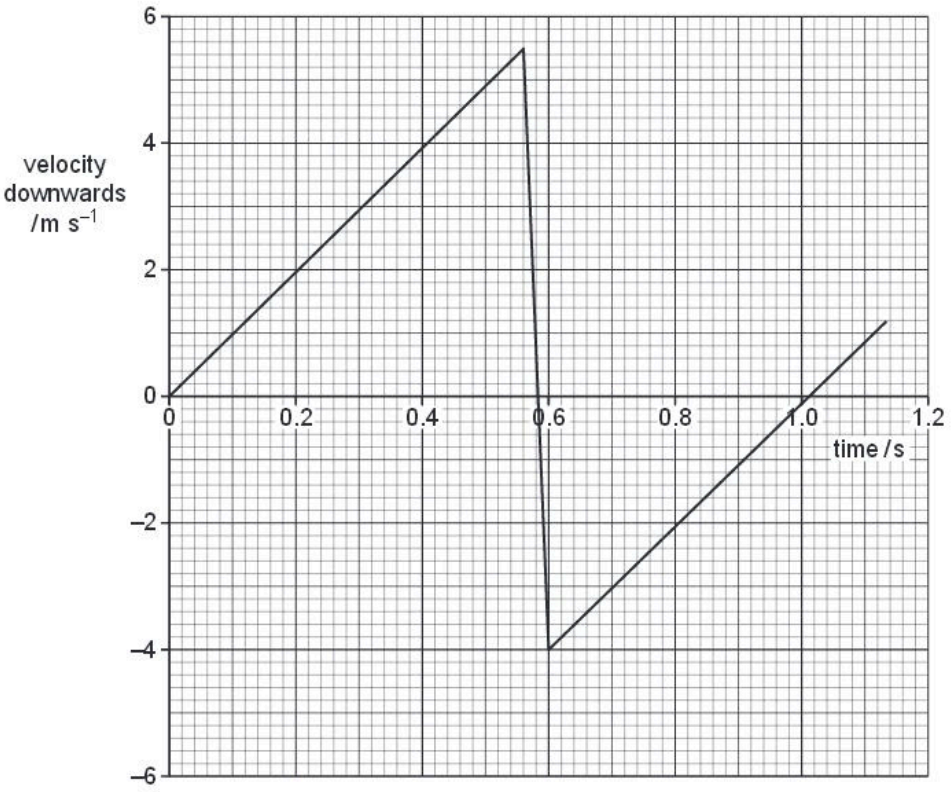


Fig. 3.1

The support A is 45 cm from the centre of gravity C of the bar and support B is 25 cm from C.

A ball of mass 140 g falls vertically onto the bar such that it hits the bar at a distance of 50 cm from C, as shown in Fig. 3.1.
The variation with time t of the velocity v of the ball before, during and after hitting the bar is shown in Fig. 3.2.



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For the time that the ball is in contact with the bar, use Fig. 3.2

For Examiner Use

(i) to determine the change in momentum of the ball,

change = ... $kg\,m\,s^{-1}$ [2]

(ii) to show that the force exerted by the ball on the bar is 33 N.

[1]

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(c) For the time that the ball is in contact with the bar, use data from Fig. 3.1 and **(b)(ii)** to calculate the force exerted on the bar by

(i) the support A,

force = ... N [3]

(ii) the support B.

force = ... N [2]

Q34.

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

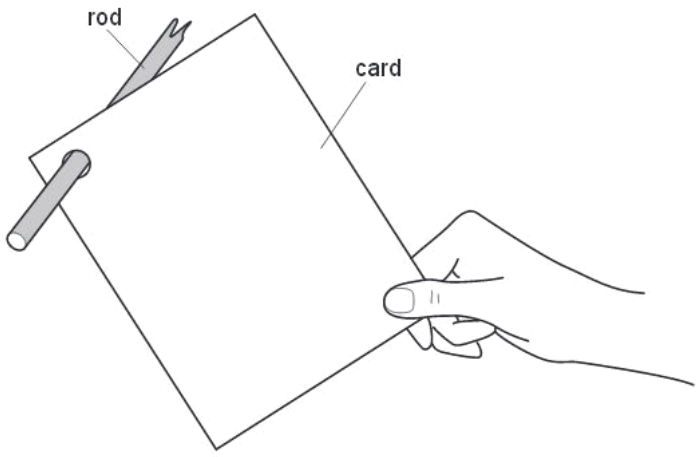
For Examiner's Use

.....

.....

.....[2]

(b) A uniform rectangular sheet of card of weight *W* is suspended from a wooden rod. The card is held to one side, as shown in Fig. 3.1.



On Fig. 3.1,

(i) mark, and label with the letter C, the position of the centre of gravity of the card, [1]

(ii) mark with an arrow labelled *W* the weight of the card. [1]

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(c) The card in **(b)** is released. The card swings on the rod and eventually comes to rest.

For Examiner Use

(i) List the two forces, other than its weight and air resistance, that act on the card during the time that it is swinging. State where the forces act.

1. .....

.....

2. .....

.....

[3]

(ii) By reference to the completed diagram of Fig. 3.1, state the position in which the card comes to rest.
Explain why the card comes to rest in this position.

.....

.....

.....[2]

Q35.

2 **(a)** Define the *torque* of a couple.

.....

..... [2]

(b) A uniform rod of length 1.5 m and weight 2.4 N is shown in Fig. 2.1.

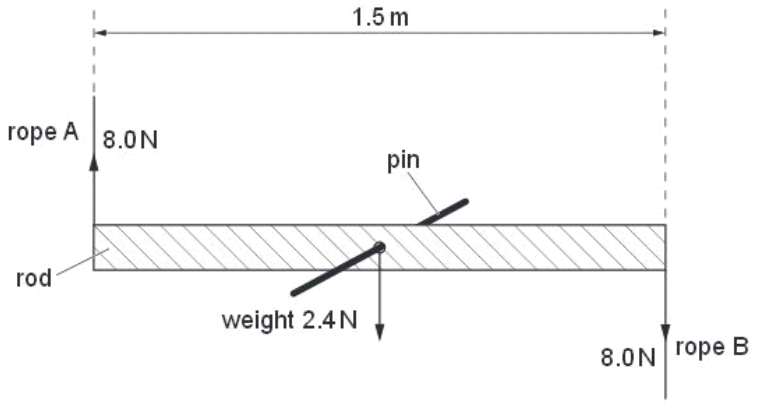


Fig. 2.1

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The rod is supported on a pin passing through a hole in its centre. Ropes A and B provide equal and opposite forces of 8.0 N.

(i) Calculate the torque on the rod produced by ropes A and B.

torque = ... Nm [1]

(ii) Discuss, briefly, whether the rod is in equilibrium.

.....

.....

.....

..... [2]

(c) The rod in **(b)** is removed from the pin and supported by ropes A and B, as shown in Fig. 2.2.

For Examiner's Use

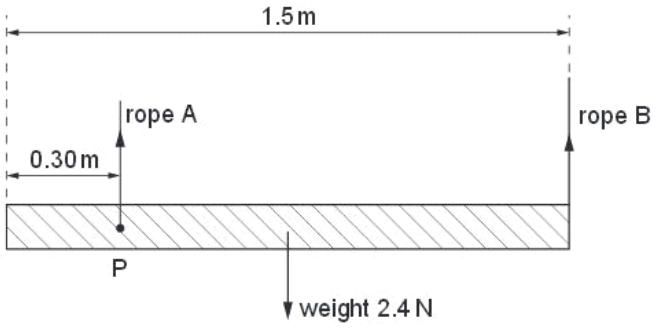


Fig. 2.2

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Rope A is now at point P 0.30 m from one end of the rod and rope B is at the other end.

(i) Calculate the tension in rope B.

tension in B = ... N [2]

(ii) Calculate the tension in rope A.

tension in A = ... N [1]

Q36.

2 **(a)** Define

(i) *force*,

.....

.....[1]

(ii) *work done*.

.....

.....[1]

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(b) A force F acts on a mass m along a straight line for a distance s. The acceleration of the mass is a and the speed changes from an initial speed u to a final speed v.

(i) State the work W done by F.

[1]

(ii) Use your answer in **(i)** and an equation of motion to show that kinetic energy of a mass can be given by the expression

$$\text{kinetic energy} = \tfrac{1}{2} \times \text{mass} \times (\text{speed})^2.$$

[3]

(c) A resultant force of 3800 N causes a car of mass of 1500 kg to accelerate from an initial speed of $15\,\text{m s}^{-1}$ to a final speed of $30\,\text{m s}^{-1}$.

(i) Calculate the distance moved by the car during this acceleration.

distance = ... m [2]

(ii) The same force is used to change the speed of the car from $30\,\text{m s}^{-1}$ to $45\,\text{m s}^{-1}$. Explain why the distance moved is not the same as that calculated in **(i)**.

.....

.....

.....[1]

Q37.

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1 **(a)** Distinguish between scalars and vectors.

.....

.....[1]

(b) Underline **all** the vector quantities in the list below.

acceleration kinetic energy momentum power weight [2]

(c) A force of 7.5 N acts at 40° to the horizontal, as shown in Fig. 1.1.

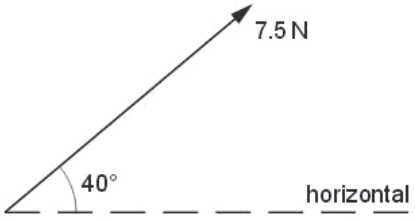


Fig. 1.1

Calculate the component of the force that acts

(i) horizontally,

horizontal component = ... N [1]

(ii) vertically.

vertical component = ... N [1]

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(d) Two strings support a load of weight 7.5 N, as shown in Fig. 1.2.

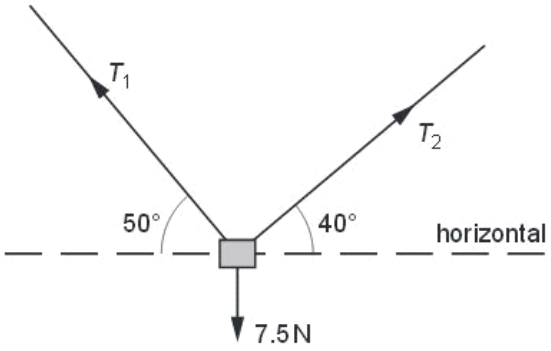


Fig. 1.2

One string has a tension T_1 and is at an angle 50° to the horizontal. The other string has a tension T_2 and is at an angle 40° to the horizontal. The object is in equilibrium. Determine the values of T_1 and T_2 by using a vector triangle or by resolving forces.

T_1 = ... N

T_2 = ... N

[4]

Q38.

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1 (a) (i) Define *acceleration*.

.....

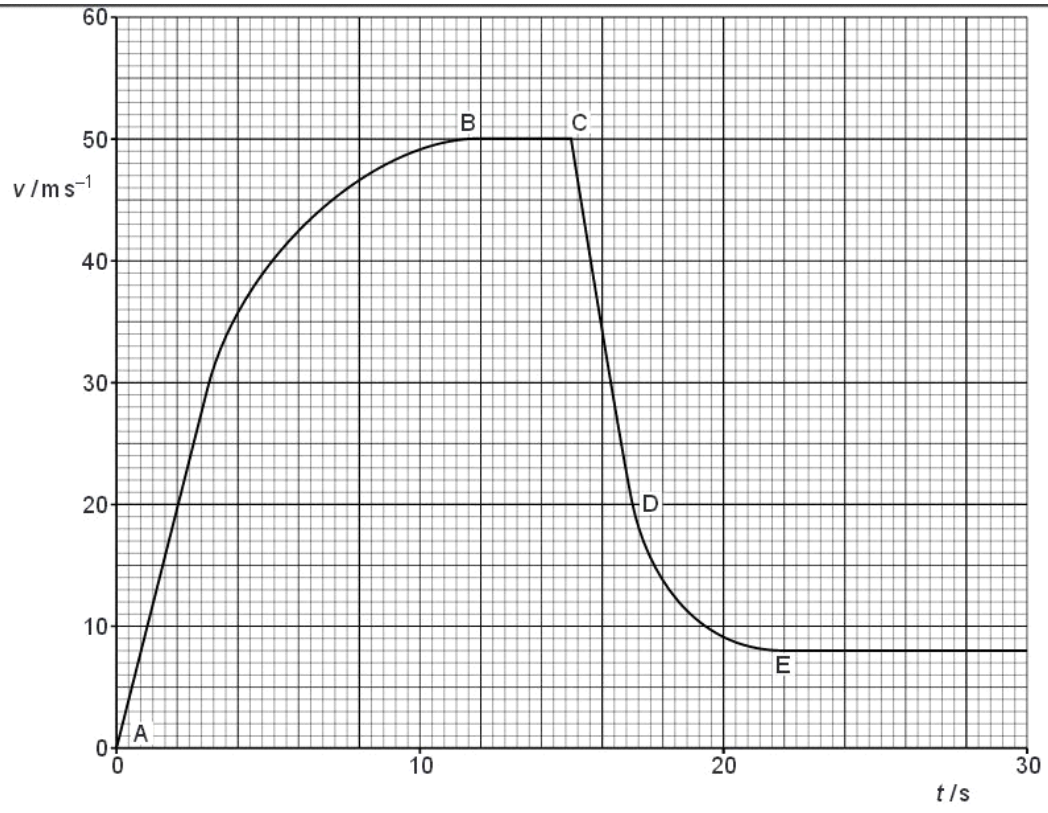
..... [1]

(ii) State Newton's first law of motion.

.....

..... [1]

(b) The variation with time t of vertical speed v of a parachutist falling from an aircraft is shown in Fig. 1.1.



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(i) Calculate the distance travelled by the parachutist in the first 3.0 s of the motion.

distance = ... m [2]

(ii) Explain the variation of the resultant force acting on the parachutist from t = 0 (point A) to t = 15 s (point C).

.....

.....

.....

.....

..... [3]

(iii) Describe the changes to the frictional force on the parachutist

1. at t = 15 s (point C),

.....

.....

..... [1]

2. between t = 15 s (point C) and t = 22 s (point E).

.....

.....

..... [1]

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(iv) The mass of the parachutist is 95 kg.

For Examiner's Use

Calculate, for the parachutist between $t = 15$ s (point C) and $t = 17$ s (point D),

1. the average acceleration,

acceleration = ... $m\,s^{-2}$ [2]

2. the average frictional force.

frictional force = ... N [3]

Q39.

2 **(a)** State Newton's second law.

.....

.....[1]

(b) A ball of mass 65 g hits a wall with a velocity of 5.2 $m\,s^{-1}$ perpendicular to the wall. The ball rebounds perpendicularly from the wall with a speed of 3.7 $m\,s^{-1}$. The contact time of the ball with the wall is 7.5 ms.

Calculate, for the ball hitting the wall,

(i) the change in momentum,

change in momentum = ... Ns [2]

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(ii) the magnitude of the average force.

force = ... N [1]

(c) **(i)** For the collision in **(b)** between the ball and the wall, state how the following apply:

1. Newton's third law,

.....

.....

.....

.....[2]

2. the law of conservation of momentum.

.....

.....[1]

(ii) State, with a reason, whether the collision is elastic or inelastic.

.....

.....[1]

Q40.

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2 Two planks of wood AB and BC are inclined at an angle of 15° to the horizontal. The two wooden planks are joined at point B, as shown in Fig. 2.1.

For Examiner Use

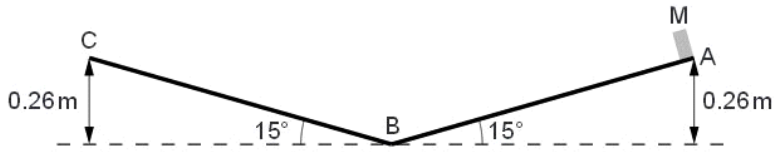


Fig. 2.1

A small block of metal M is released from rest at point A. It slides down the slope to B and up the opposite side to C. Points A and C are 0.26m above B. Assume frictional forces are negligible.

(a) (i) Describe and explain the acceleration of M as it travels from A to B and from B to C.

.....

.....

.....

..... [3]

(ii) Calculate the time taken for M to travel from A to B.

time = ... s [3]

(iii) Calculate the speed of M at B.

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

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(b) The plank BC is adjusted so that the angle it makes with the horizontal is 30°. M is released from rest at point A and slides down the slope to B. It then slides a distance along the plank from B towards C.

Use the law of conservation of energy to calculate this distance. Explain your working.

distance = ... m [2]

Q41.

4 **(a)** Define the *torque* of a couple.

.....

.....[2]

(b) A wheel is supported by a pin P at its centre of gravity, as shown in Fig. 4.1.

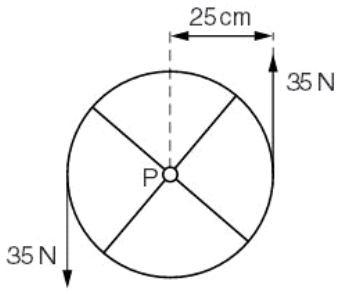


Fig. 4.1

The plane of the wheel is vertical. The wheel has radius 25 cm.
Two parallel forces each of 35 N act on the edge of the wheel in the vertical directions shown in Fig. 4.1. Friction between the pin and the wheel is negligible.

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(i) List two other forces that act on the wheel. State the direction of these forces and where they act.

1. .....

2. .....
[2]

(ii) Calculate the torque of the couple acting on the wheel.

torque = ... Nm [2]

(iii) The resultant force on the wheel is zero. Explain, by reference to the four forces acting on the wheel, how it is possible that the resultant force is zero.

.....

.....[1]

(iv) State and explain whether the wheel is in equilibrium.

.....[1]

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Dynamics - 2018

1. 9702/11/M/J/18/No.8

The momentum of a car of mass m increases from p_1 to p_2.

What is the increase in the kinetic energy of the car?

A $\frac{(p_2^2 - p_1^2)}{2m}$ **B** $\frac{(p_2 - p_1)^2}{2m}$ **C** $\frac{p_2 - p_1}{2m}$ **D** $\frac{p_1 - p_2}{2m}$

$K.E = \frac{1}{2}mv^2$

$\Delta E_k = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$= \frac{1}{2}m(v^2 - u^2) \times \frac{m}{m}$

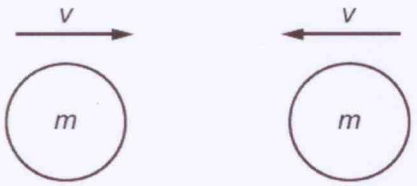
$= \frac{m^2(v^2 - u^2)}{2m}$

$= \frac{m^2v^2 - m^2u^2}{2m}$

$= \frac{p_2^2 - p_1^2}{2m}$

2. 9702/11/M/J/18/No.9

Two similar spheres, each of mass m and travelling with speed v, are moving towards each other.



The spheres have a head-on elastic collision.

$E_k = \frac{1}{2}mv^2 + \frac{1}{2}mv^2$

$= mv^2$

Which statement is correct?

A The spheres stick together on impact.

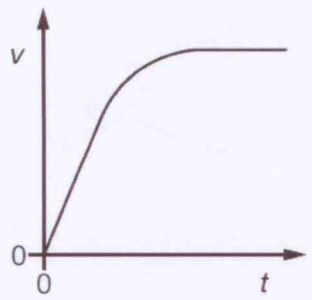
B The total kinetic energy after impact is mv^2.

C The total kinetic energy before impact is zero.

D The total momentum before impact is $2mv$.

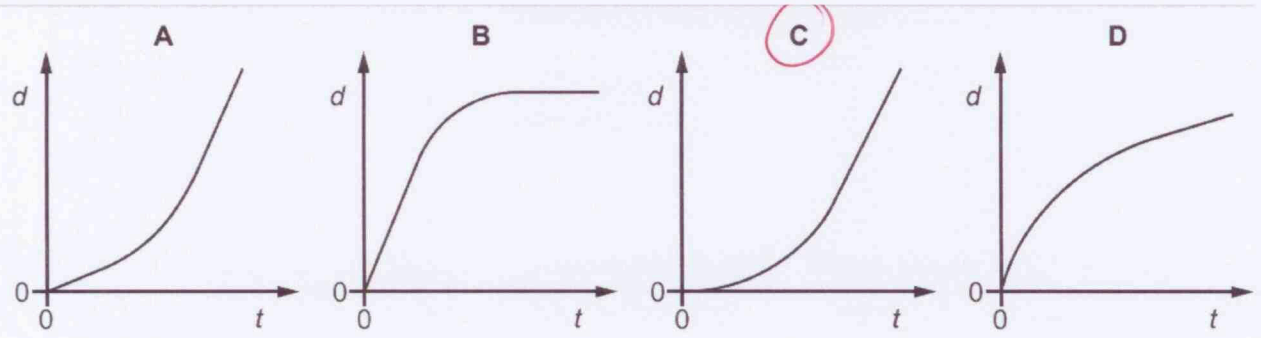
3. 9702/12/M/J/18/No.7

A sky-diver falls vertically from a helicopter and reaches constant (terminal) velocity. The graph shows the variation with time t of the speed v of the sky-diver.



Which graph shows the variation with time t of the distance d fallen by the sky-diver?

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4. 9702/12/M/J/18/No.8

A tennis ball of mass 55 g is travelling horizontally with a speed of $30\,m\,s^{-1}$. The ball makes contact with a wall before rebounding in the horizontal direction with a speed of $20\,m\,s^{-1}$. The ball is in contact with the wall for a time of 5.0×10^{-3} s.

What is the average force exerted on the wall by the ball?

A 110 N **B** 220 N **C** 330 N **D** 550 N

$F = \frac{\Delta p}{\Delta t}$

$= \frac{-mv - mu}{\Delta t}$

$= \frac{0.055(-20-30)}{5.0\times10^{-3}}$

$= 550\,N$

5. 9702/12/M/J/18/No.9

An elastic collision occurs between two bodies X and Y. The mass of body X is m and the mass of body Y is $4m$. Body X travels at speed v before the collision and speed $\frac{3v}{5}$ in the opposite direction after the collision. Body Y is stationary before the collision.



$E_K = \frac{1}{2}mv^2$ before $E_K = 0$

$E_K = \frac{1}{2}m\left(\frac{3v}{5}\right)^2 = \frac{9}{50}mv^2$ after E_{K4}

What is the kinetic energy of body Y after the collision?

A $\frac{8}{10}mv^2$ **B** $\frac{34}{50}mv^2$ **C** $\frac{16}{50}mv^2$ **D** $\frac{1}{5}mv^2$

$\frac{1}{2}mv^2 + 0 = \frac{9}{50}mv^2 + E_{K4}$

$E_{K4} = \left(\frac{1}{2} - \frac{9}{50}\right)mv^2$

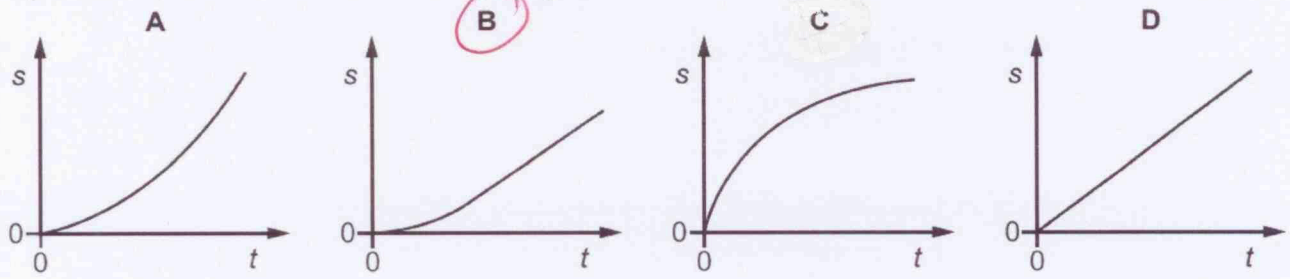
$= \frac{16}{50}mv^2$

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6. 9702/13/M/J/18/No.8

A sky-diver falls from a stationary balloon at time $t = 0$. As the sky-diver falls, her speed and the air resistance increase until the force of the air resistance is equal to her weight.

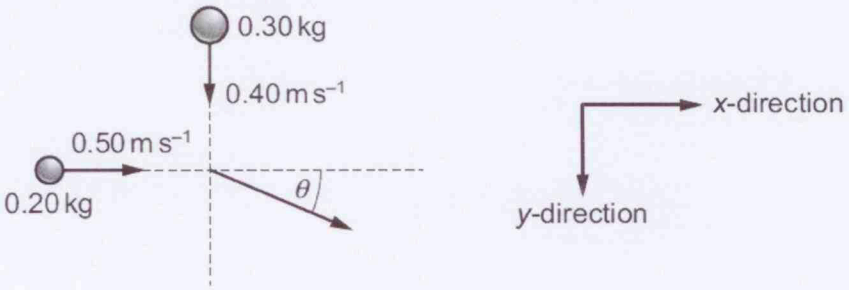
Which graph best shows the variation with time t of the displacement s for the motion of the sky-diver?



7. 9702/13/M/J/18/No.9

A ball of mass 0.20 kg, travelling in the x-direction at a speed of 0.50 m s^{-1}, collides with a ball of mass 0.30 kg travelling in the y-direction at a speed of 0.40 m s^{-1}.

The two balls stick together after the collision, travelling at an angle θ to the x-direction.



What is the value of θ?

A 39° **B** 40° **C** 50° **D** 51°

before collision

p in x direction

$0.2 \times 0.5 = 0.1$ kg m s^{-1}

p in y direction

$0.3 \times 0.4 = 0.12$ kg m s^{-1}

after collision

p in x direction

$(0.2+0.3)v\cos\theta = 0.5v\cos\theta$

p in y direction

$(0.2+0.3)v\sin\theta = 0.5v\sin\theta$

$0.1 = 0.5v\cos\theta$

$v = \frac{0.2}{\cos\theta}$

$0.12 = 0.5v\sin\theta$

$v = \frac{0.24}{\sin\theta}$

$\frac{0.2}{\cos\theta} = \frac{0.24}{\sin\theta}$

$\frac{\sin\theta}{\cos\theta} = \frac{0.24}{0.2}$

$\frac{\sin\theta}{\cos\theta} = \tan\theta$

$\tan\theta = \frac{0.24}{0.2}$

$\tan\theta = 1.2$

$\theta = \tan^{-1}(1.2)$

$= 50.19^\circ$

$\simeq 50^\circ$

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8. 9702/12/F/M/18/No.10

Steel pellets, each with a mass of 0.60 g, fall vertically onto a horizontal plate at a rate of 100 pellets per minute. They strike the plate with a velocity of 5.0 m s^{-1} and rebound with a velocity of 4.0 m s^{-1}.

↑ change direction

What is the average force exerted on the plate by the pellets?

A 0.0010 N **B** 0.0054 N **C** 0.0090 N **D** 0.54 N

$$F = \frac{mv - mu}{\Delta t}$$

$$= \frac{m(v-u)}{\Delta t}$$

$$= \frac{m(-4-5)}{\frac{60}{100}\,s}$$

$$= \frac{0.0006(-4-5)}{0.6}$$

$$= \frac{0.009\ N \times 100}{100}$$

$$= 0.009\ N$$

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Dynamics – 2021 AS

1. June/2021/Paper_11/No.8

A rocket is fired from the Earth into space.

Newton's third law of motion describes how forces act in pairs. One of the forces of a pair is the weight of the rocket.

What is the other force of this pair?

A air resistance

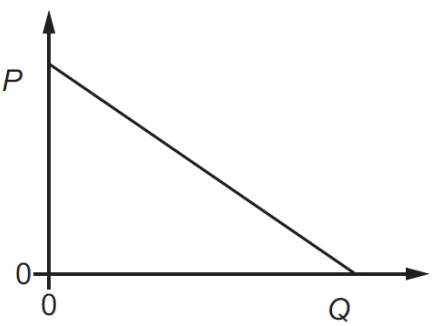
B force of the exhaust gases on the rocket

C force of the rocket on the exhaust gases

D gravitational force of the rocket on the Earth

2. June/2021/Paper_11/No.9

The graph shows how quantity *P* varies with quantity *Q* for a body falling vertically downwards in a uniform gravitational field with air resistance.



Which pair of quantities could be represented by *P* and *Q*?

	P	*Q*
A	acceleration	force of air resistance
B	acceleration	time
C	velocity	force of air resistance
D	velocity	time

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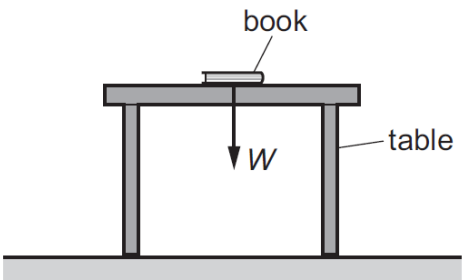
3. June/2021/Paper_11/No.10

Which quantities are conserved in an inelastic collision?

	kinetic energy	total energy	linear momentum
A	conserved	not conserved	conserved
B	conserved	not conserved	not conserved
C	not conserved	conserved	conserved
D	not conserved	conserved	not conserved

4. June/2021/Paper_12/No.8

A book of weight *W* is at rest on a table. A student attempts to state Newton's third law of motion by saying that 'action equals reaction'.



If the weight of the book is the 'action' force, what is the 'reaction' force?

A the force *W* acting downwards on the Earth from the table

B the force *W* acting upwards on the book from the table

C the force *W* acting upwards on the Earth from the book

D the force *W* acting upwards on the table from the floor

5. June/2021/Paper_12/No.9

Four balls are dropped at the same time from the top of a very tall tower. There is no wind blowing.

Which ball hits the ground first?

A



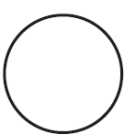
mass *M*
diameter *D*

B



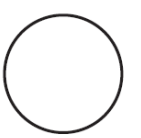
mass 4*M*
diameter *D*

C



mass *M*
diameter 2*D*

D



mass 4*M*
diameter 2*D*

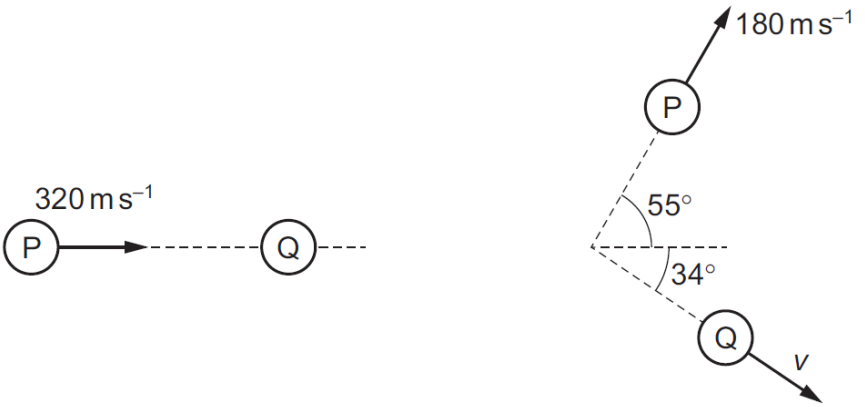
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6. June/2021/Paper_12/No.10

A nitrogen molecule P travelling at a speed of 320 $m\,s^{-1}$ in a vacuum collides with a stationary nitrogen molecule Q.

After the collision, P travels at a velocity of 180 $m\,s^{-1}$ at an angle of 55° to its original path.

Q travels in a direction at an angle of 34° to the initial path of P.



before collision after collision

Assume that there are no external forces acting on the molecules.

What is the magnitude v of the velocity of Q after the collision?

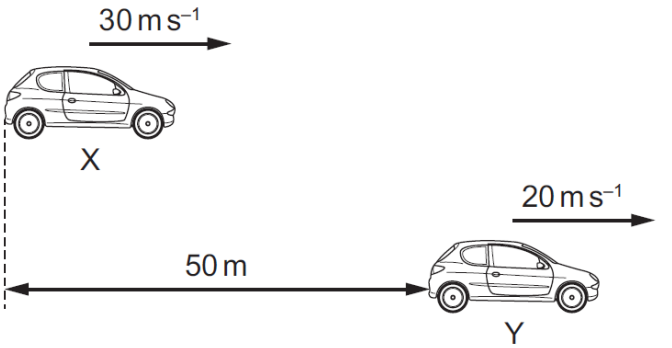
A 120 $m\,s^{-1}$ **B** 140 $m\,s^{-1}$ **C** 180 $m\,s^{-1}$ **D** 260 $m\,s^{-1}$

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7. Nov/2021/Paper_11/No.7

They are travelling in the same direction.

X is 50 m behind Y and has a constant velocity of 30 m s^{-1}. Y has a constant velocity of 20 m s^{-1}.



What is the value of *t* when X is level with Y?

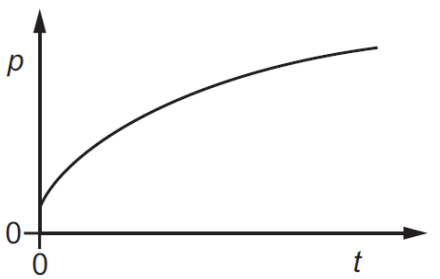
A 1.0 s **B** 1.7 s **C** 2.5 s **D** 5.0 s

8. Nov/2021/Paper_11/No.8

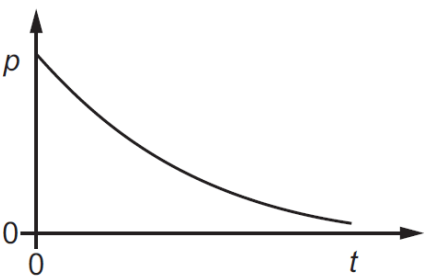
A constant resultant force acts on an object in the direction of the object's velocity.

Which graph could show the variation with time *t* of the momentum *p* of the object?

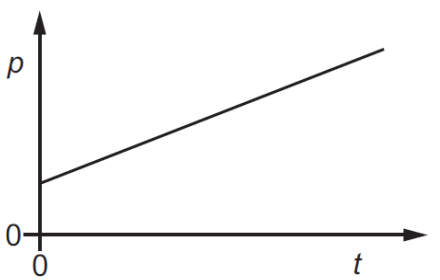
A



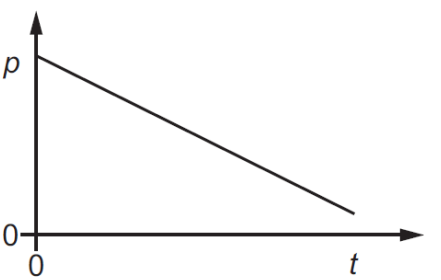
B



C



D



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9. Nov/2021/Paper_11/No.9

Which statement **must** be true for an object in a gravitational field?

A If the object has mass then the field causes it to accelerate.

B If the object has mass then the field causes it to have weight.

C If the object has weight then the field causes it to accelerate.

D If the object has weight then the field causes it to have mass.

10. Nov/2021/Paper_11/No.10

A ball of mass 0.16 kg is travelling horizontally at a speed of 20 $m\,s^{-1}$.

It collides with a wall and rebounds with a speed of 15 $m\,s^{-1}$ along its original path. The ball is in contact with the wall for a time of 1.0 ms.

What is the average force exerted by the wall on the ball?

A 800 N **B** 2400 N **C** 3200 N **D** 5600 N

11. Nov/2021/Paper_12/No.8

What is meant by the mass of an object?

A the property of the object that resists a change in motion

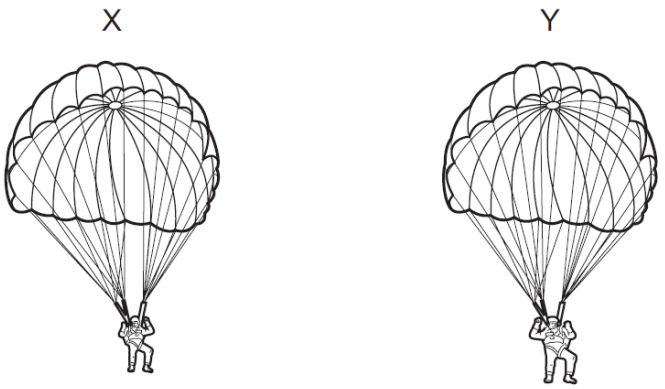
B the pull of the Earth on the object

C the total number of atoms in the object

D the weight of the object

12. Nov/2021/Paper_12/No.9

The diagram shows two parachutists, X and Y, moving vertically downwards.



The total mass of parachutist Y and his parachute is twice the total mass of parachutist X and his parachute. At this moment, the air resistance on parachute Y is twice the air resistance on parachute X. Neither parachutist has reached his constant (terminal) velocity.

Which statement describes the acceleration of Y compared with the acceleration of X?

A The acceleration of Y is half the acceleration of X.

B The acceleration of Y is the same as the acceleration of X.

C The acceleration of Y is more than the acceleration of X, but less than twice the value.

D The acceleration of Y is twice the acceleration of X.

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13. Nov/2021/Paper_12/No.10

The table shows four different collisions between two blocks, each of mass 0.50 kg.

Which collision is perfectly elastic?

	before collision	after collision
A	$4.0\,m\,s^{-1}$ → 0.50 kg $0.0\,m\,s^{-1}$ 0.50 kg	$2.0\,m\,s^{-1}$ → 0.50 kg | 0.50 kg
B	$2.0\,m\,s^{-1}$ → 0.50 kg ← $2.0\,m\,s^{-1}$ 0.50 kg	$0.0\,m\,s^{-1}$ 0.50 kg | 0.50 kg
C	$2.0\,m\,s^{-1}$ → 0.50 kg ← $1.0\,m\,s^{-1}$ 0.50 kg	← $2.0\,m\,s^{-1}$ 0.50 kg $3.0\,m\,s^{-1}$ → 0.50 kg
D	$4.0\,m\,s^{-1}$ → 0.50 kg $1.0\,m\,s^{-1}$ → 0.50 kg	$1.0\,m\,s^{-1}$ → 0.50 kg $4.0\,m\,s^{-1}$ → 0.50 kg

14. Nov/2021/Paper_13/No.8

Water is pumped through a hose-pipe at a rate of 90 kg per minute. Water emerges horizontally from the hose-pipe with a speed of $20\,m\,s^{-1}$.

What is the minimum force required from a person holding the hose-pipe to prevent it moving backwards?

A 30 N **B** 270 N **C** 1800 N **D** 110 000 N

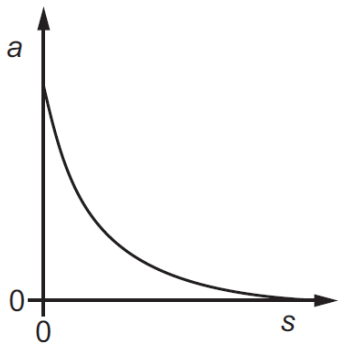
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15. Nov/2021/Paper_13/No.9

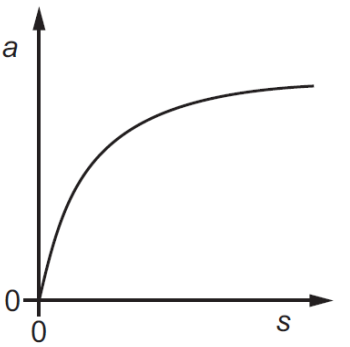
A skydiver leaves a stationary balloon and falls vertically through a long distance.

Which graph best represents the variation of the acceleration *a* of the skydiver with the distance *s* travelled as she falls through the air?

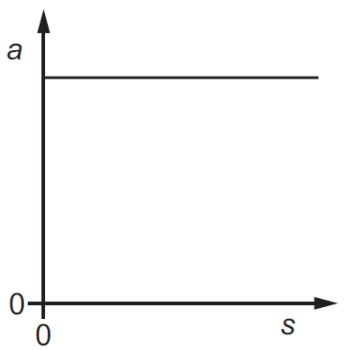
A



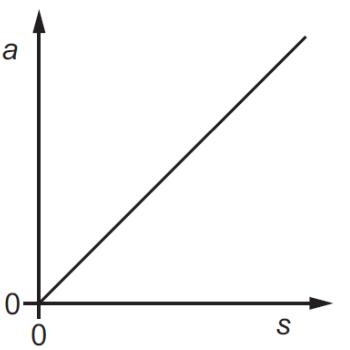
B



C



D



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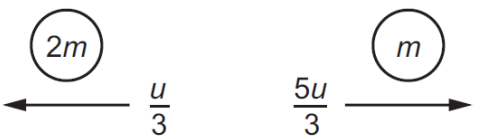
16. Nov/2021/Paper_13/No.10

The diagram shows two spheres approaching each other head-on. Each sphere has speed u. One sphere has mass $2m$ and the other has mass m.

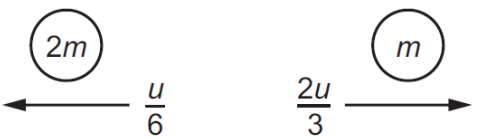


Which diagram shows the result of a perfectly elastic collision?

A



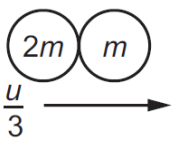
B



C



D



the spheres stick together

17. Nov/2021/Paper_13/No.11

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

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

A



B



C



D



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1. Nov/2021/Paper_21/No.2

(a) Define *momentum*.

.....

..... [1]

(b) Two balls X and Y, of equal diameter but different masses 0.24 kg and 0.12 kg respectively, slide towards each other on a frictionless horizontal surface, as shown in Fig. 2.1.

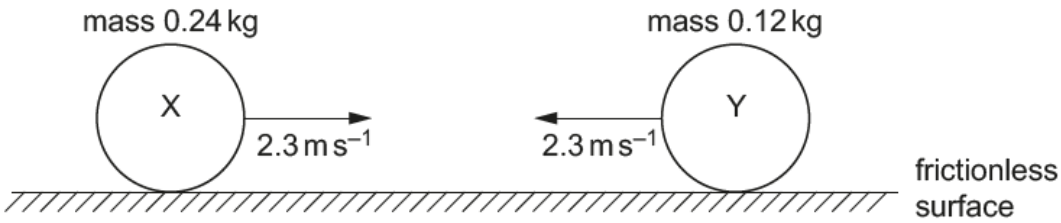


Fig. 2.1

Both balls have initial speed 2.3 m s^{-1} before they collide with each other. Fig. 2.2 shows the variation with time t of the force F_Y exerted on ball Y by ball X during the collision.

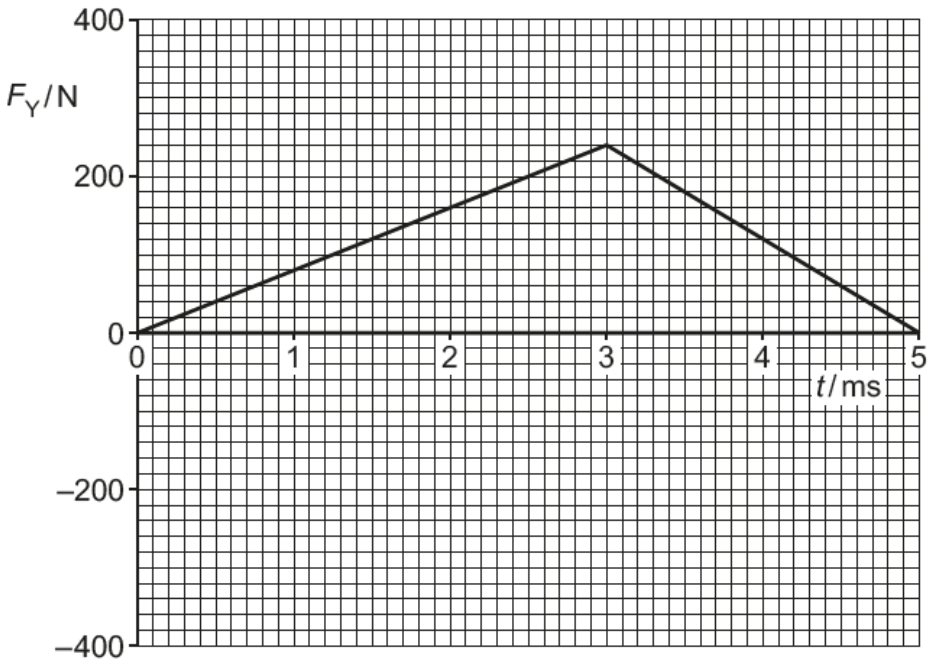


Fig. 2.2

(i) Calculate the kinetic energy of ball X before the collision.

kinetic energy = ... J [3]

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(ii) The area enclosed by the lines and the time axis in Fig. 2.2 represents the change in momentum of ball Y during the collision.

Determine the magnitude of the change in momentum of ball Y.

change in momentum = ... Ns [2]

(iii) Calculate the magnitude of the velocity of ball Y after the collision.

velocity = ... ms^{-1} [2]

(c) On Fig. 2.3, sketch the variation with time t of the force F_X exerted on ball X by ball Y during the collision in **(b)**.

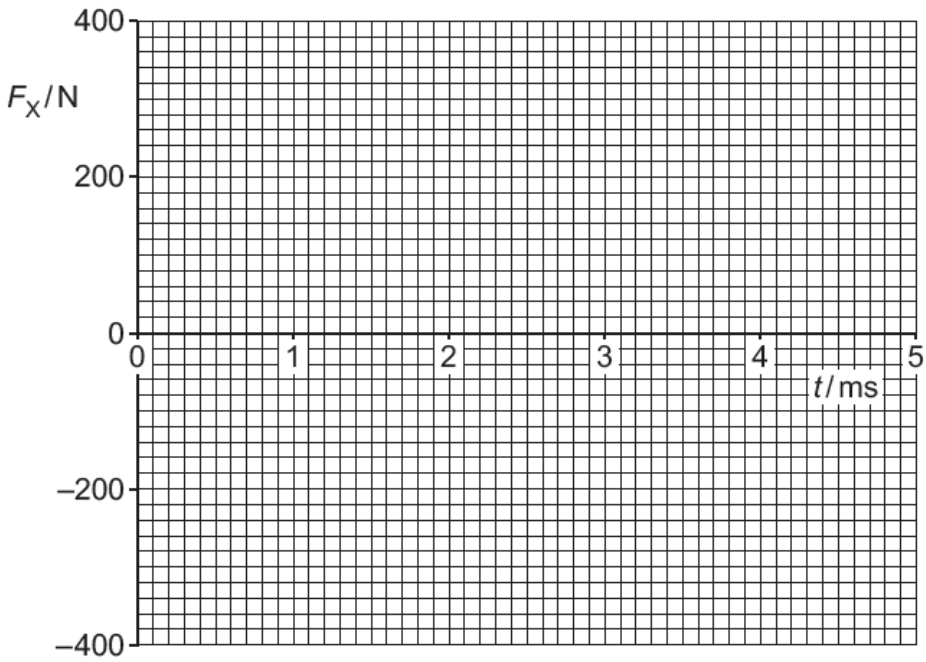


Fig. 2.3

[3]

[Total: 11]

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2. Nov/2021/Paper_23/No.3c

(c) The engine of the aircraft in **(b)** stops. The aircraft then glides towards the ground with a constant velocity at an angle θ to the horizontal, as illustrated in Fig. 3.2.

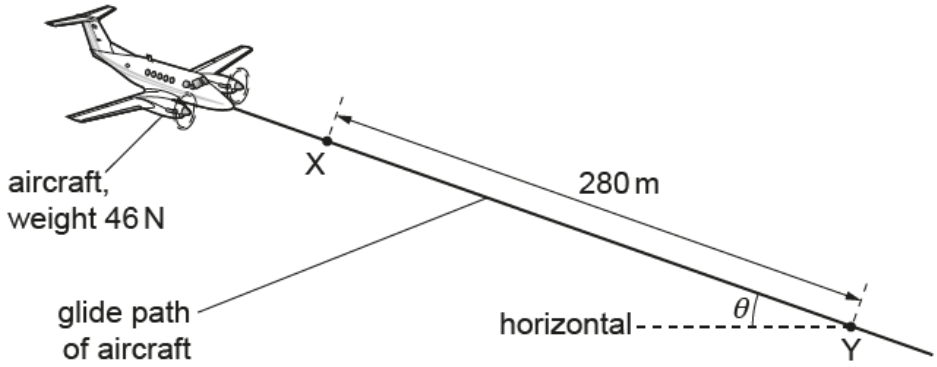


Fig. 3.2 (not to scale)

The aircraft has a weight of 46 N and travels a distance of 280 m from point X to point Y. The change in gravitational potential energy of the aircraft for its movement from X to Y is 6100 J.

Assume that there is now no wind.

(i) Calculate angle θ.

θ = ... ° [3]

(ii) Calculate the magnitude of the force acting on the aircraft due to air resistance.

force = ... N [2]

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3. June/2021/Paper_22/No.2

A ball is thrown vertically downwards to the ground, as illustrated in Fig. 2.1.

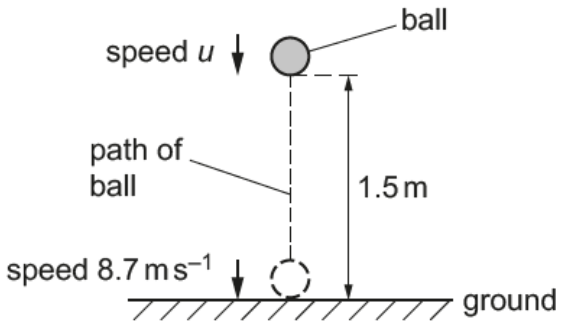


Fig. 2.1

The ball is thrown with speed u from a height of 1.5 m. The ball then hits the ground with speed 8.7 m s^{-1}. Assume that air resistance is negligible.

(a) Calculate speed u.

u = ... m s^{-1} [2]

(b) State how Newton's third law applies to the collision between the ball and the ground.

.....

.....

.....

..... [2]

(c) The ball is in contact with the ground for a time of 0.091 s. The ball rebounds vertically and leaves the ground with speed 5.4 m s^{-1}. The mass of the ball is 0.059 kg.

(i) Calculate the magnitude of the change in momentum of the ball during the collision.

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

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(ii) Determine the magnitude of the average resultant force that acts on the ball during the collision.

average resultant force = ... N [1]

(iii) Use your answer in **(c)(ii)** to calculate the magnitude of the average force exerted by the ground on the ball during the collision.

average force = ... N [2]

(d) The ball was thrown downwards at time $t = 0$ and hits the ground at time $t = T$.

On Fig. 2.2, sketch a graph to show the variation of the speed of the ball with time t from $t = 0$ to $t = T$. Numerical values are not required.

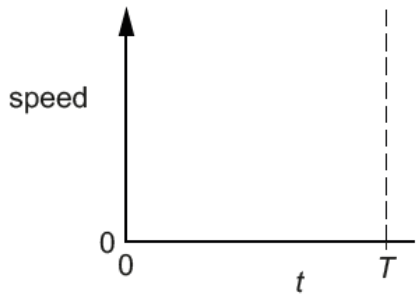


Fig. 2.2

[1]

(e) In practice, air resistance is not negligible.

State and explain the variation, if any, with time t of the gradient of the graph in **(d)** when air resistance is not negligible.

.....

.....

.....

..... [2]

[Total: 12]

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4. June/2021/Paper_23/No.2

(a) Define *acceleration*.

.....

..... [1]

(b) A stone falls vertically from the top of a cliff. Fig. 2.1 shows the variation with time t of the velocity v of the stone.

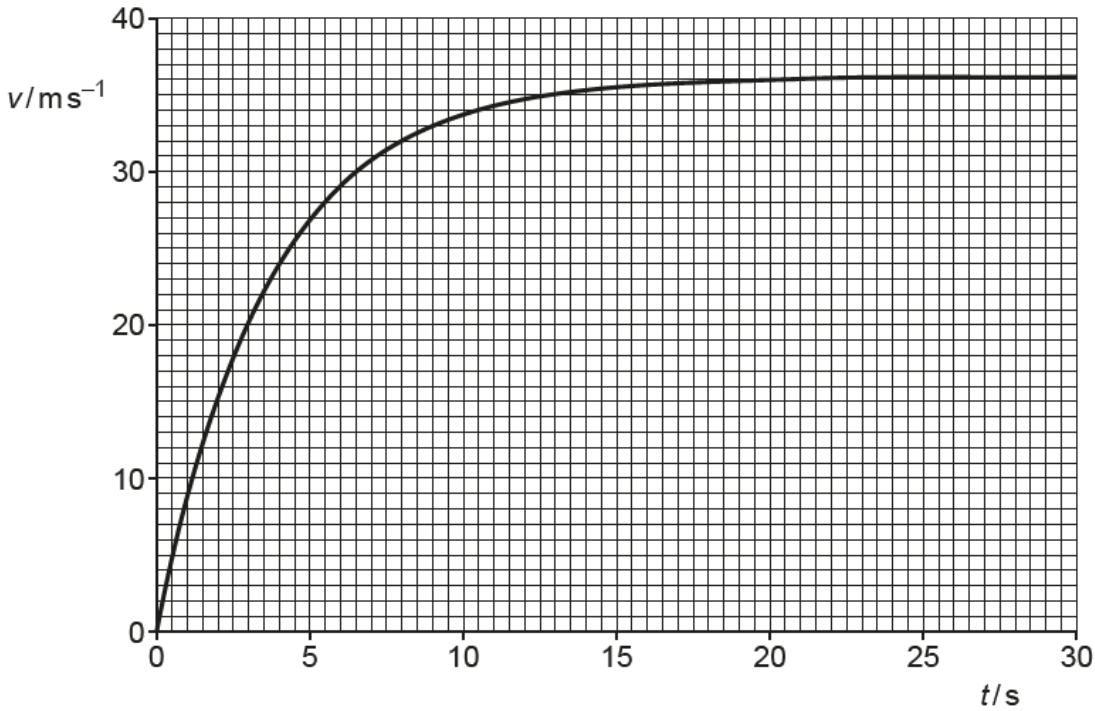


Fig. 2.1

(i) Explain, with reference to forces acting on the stone, the shape of the curve in Fig. 2.1.

.....

.....

.....

.....

..... [3]

(ii) Use Fig. 2.1 to determine the speed of the stone when the resultant force on it is zero.

speed = ... $m s^{-1}$ [1]

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(iii) Use Fig. 2.1 to calculate the approximate height through which the stone falls between $t = 0$ and $t = 30\,s$.

height = ... m [3]

(iv) On Fig. 2.2, sketch the variation with t of the acceleration a of the stone between $t = 0$ and $t = 30\,s$.

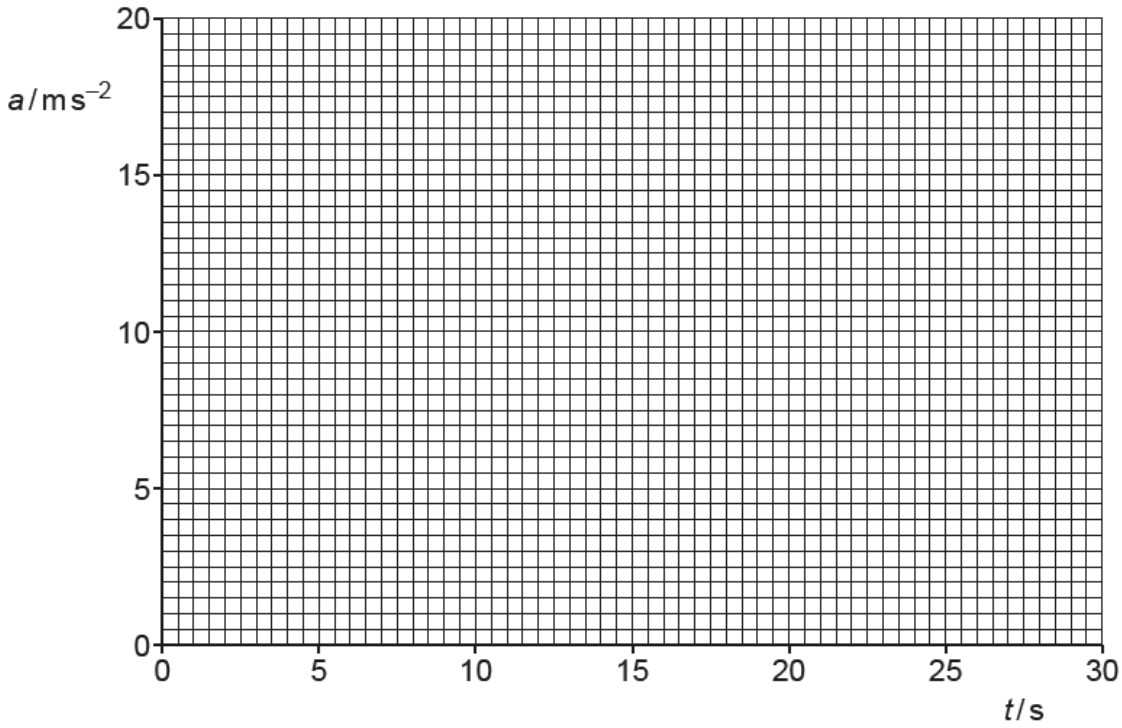


Fig. 2.2

[3]

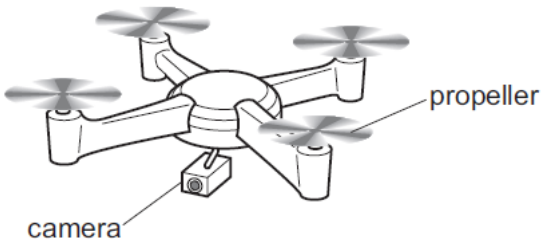
[Total: 11]

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Dynamics – 2023 June AS Physics 9702

1. June/2023/Paper_ 9702/11/No.7

A camera drone of mass 1.20 kg hovers at a fixed point above the ground. The drone has four propellers.



In a time of 1.00 s, each propeller pushes a mass of 0.400 kg of air vertically downwards.

Assume that the air above the propellers is stationary.

What is the speed of the air leaving each propeller?

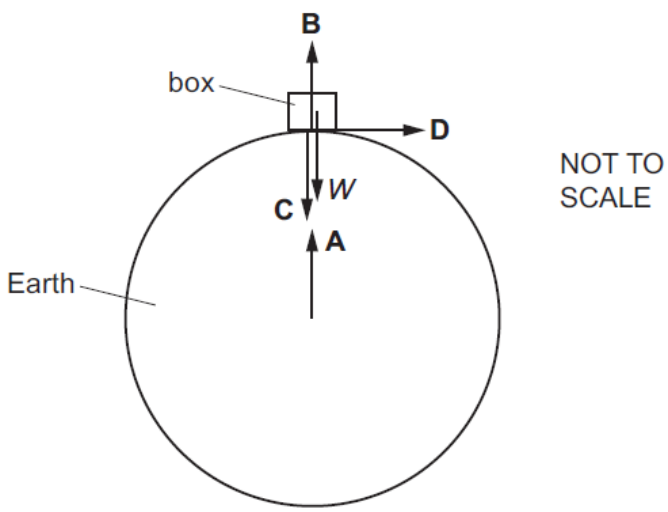
A $0.750\,m\,s^{-1}$ **B** $3.00\,m\,s^{-1}$ **C** $7.36\,m\,s^{-1}$ **D** $29.4\,m\,s^{-1}$

2. June/2023/Paper_ 9702/11/No.8

A box rests on the Earth, as shown.

Newton's third law describes how forces of the same type act in pairs. One of the forces of a pair is the weight *W* of the box.

Which arrow represents the other force of this pair?

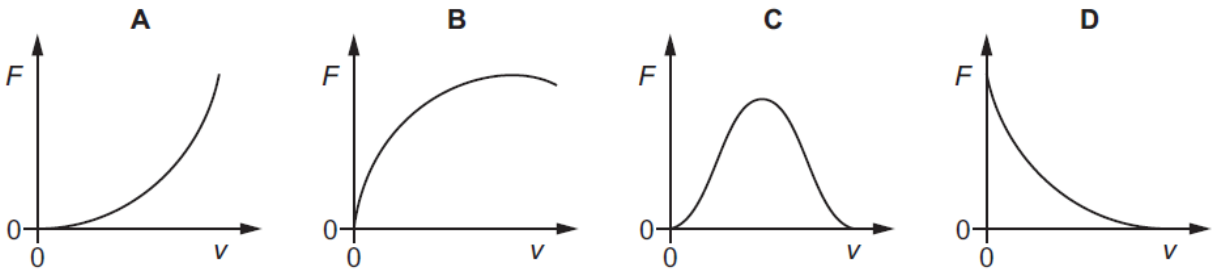


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3. June/2023/Paper_ 9702/11/No.9

A small ball is held at the surface of liquid oil in a container. The ball is released from rest and falls through the oil. The ball has velocity v. A viscous (drag) force F acts on the ball.

Which graph could show the variation with v of F?



4. June/2023/Paper_ 9702/11/No.10

An object of mass m, moving at speed u along a frictionless horizontal surface, collides head-on with a stationary object of mass $4m$.



before the collision

After the collision, the object of mass m rebounds along its initial path with $\frac{1}{4}$ of its kinetic energy before the collision.

What is the speed of the object of mass $4m$ after the collision?

A $\frac{u}{8}$ **B** $\frac{3u}{16}$ **C** $\frac{5u}{16}$ **D** $\frac{3u}{8}$

5. June/2023/Paper_ 9702/12/No.7

Which statement describes the mass of an object?

A the force the object experiences due to gravity

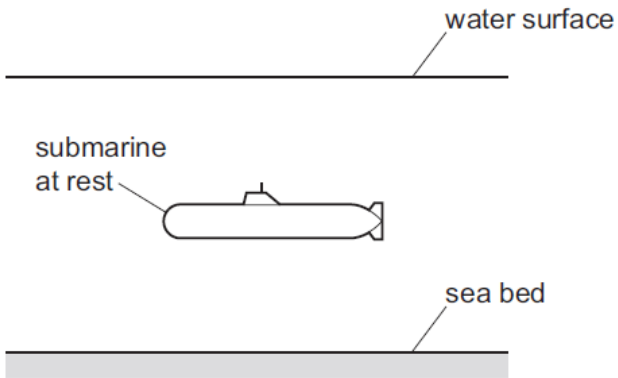
B the momentum of the object before a collision

C the resistance of the object to changes in motion

D the weight of the object as measured by a balance

6. June/2023/Paper_ 9702/12/No.8

A submarine of total mass 3200 kg is at rest underwater.



The total mass of the submarine is suddenly decreased by 200 kg by pumping water out of the submarine horizontally in a negligible time. The upthrust acting on the submarine is unchanged.

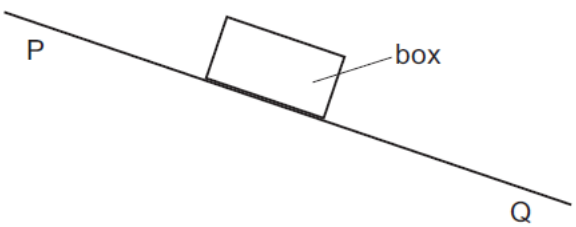
The change in the total weight of the submarine causes it to accelerate vertically upwards.

What is the initial upwards acceleration of the submarine?

A $0.613\,m\,s^{-2}$ **B** $0.654\,m\,s^{-2}$ **C** $9.81\,m\,s^{-2}$ **D** $10.5\,m\,s^{-2}$

7. June/2023/Paper_ 9702/12/No.9

A box in air slides with increasing speed down a rough slope from point P to point Q.



The slope surface exerts a constant frictional force on the box.

As the box moves from P to Q, there are changes to the magnitudes of its acceleration and the total resistive force acting on it.

Which row describes the changes?

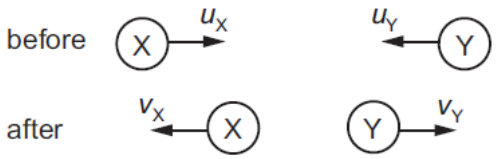
	magnitude of acceleration	magnitude of total resistive force
A	increases	decreases
B	decreases	decreases
C	increases	increases
D	decreases	increases

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8. June/2023/Paper_ 9702/12/No.10

Two balls, X and Y, approach each other along the same straight line and collide. The collision is perfectly elastic.

Their initial speeds are u_X and u_Y respectively. After the collision they move apart with speeds v_X and v_Y respectively. Their directions are shown.



Which equation is correct?

A $u_X + u_Y = v_X + v_Y$

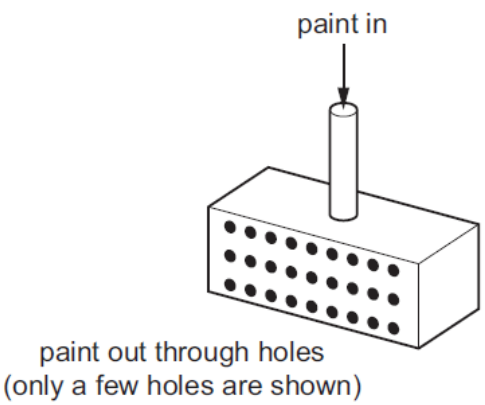
B $u_X + u_Y = v_X - v_Y$

C $u_X - u_Y = v_X + v_Y$

D $u_X - u_Y = v_X - v_Y$

9. June/2023/Paper_ 9702/13/No.7

A device for spraying paint consists of a box with its faces horizontal and vertical. One of its vertical faces contains small holes. Paint is fed into the box under pressure via a vertical tube and exits through the holes as fine streams moving horizontally.



The paint is ejected at a speed of $2.5\,m\,s^{-1}$ through 400 holes, each of area $0.4\,mm^2$. The density of the paint is $900\,kg\,m^{-3}$.

What is the horizontal force required to hold the device stationary as it ejects the paint?

A 0.36 N **B** 0.90 N **C** 2.3 N **D** 900 N

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10. June/2023/Paper_ 9702/13/No.8

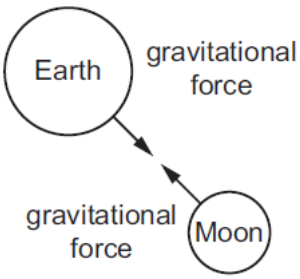
Each diagram illustrates a pair of forces of equal magnitude.

Which diagram gives an example of a pair of forces that is described by Newton's third law of motion?

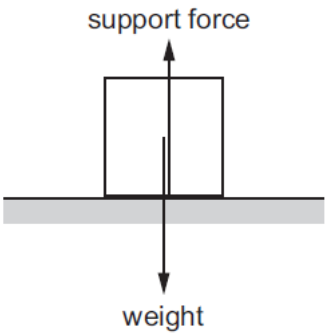
A



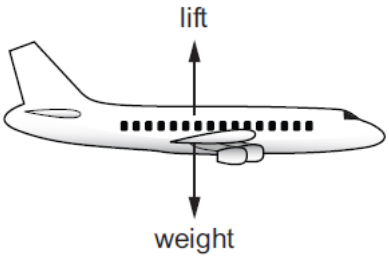
B



C



D



11. June/2023/Paper_ 9702/13/No.9

Two balls of identical shape and size but different masses are falling through the same liquid.

The sum of the drag force and upthrust acting on each ball is equal to its weight.

Which statement about the two balls is correct?

A The heavier ball has a larger acceleration than the lighter ball.

B The heavier ball has a smaller deceleration than the lighter ball.

C The heavier ball is falling at the same speed as the lighter ball.

D The heavier ball is falling at a larger speed than the lighter ball.

12. June/2023/Paper_ 9702/13/No.10

A perfectly elastic collision occurs between two objects X and Y. The mass of X is m and the mass of Y is $4m$. Object X travels at speed v before the collision and speed $\frac{3v}{5}$ in the opposite direction after the collision. Object Y is stationary before the collision.



What is the kinetic energy of Y after the collision?

A $\frac{8}{10}mv^2$ **B** $\frac{34}{50}mv^2$ **C** $\frac{16}{50}mv^2$ **D** $\frac{1}{5}mv^2$

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13. June/2023/Paper_ 9702/21/No.3

A block is pulled in a straight line along a rough horizontal surface by a varying force X, as shown in Fig. 3.1.

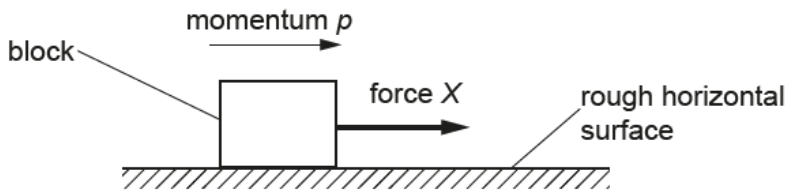


Fig. 3.1

Air resistance is negligible. Assume that the frictional force exerted on the block by the surface is constant and has magnitude 2.0 N.

The variation with time t of the momentum p of the block is shown in Fig. 3.2.

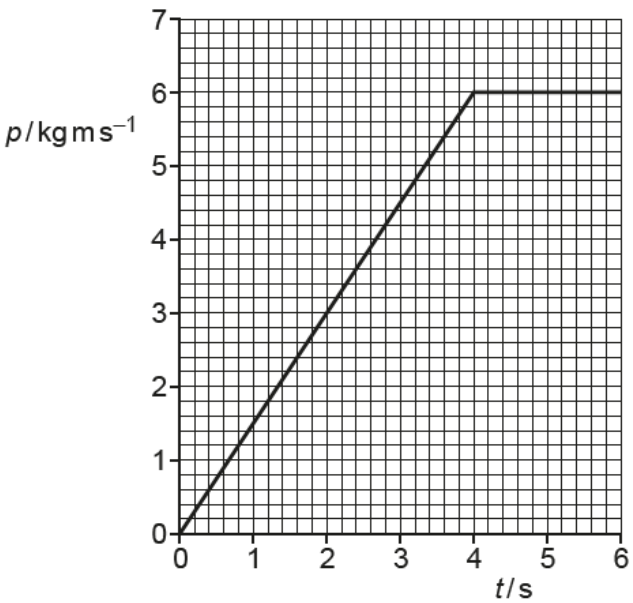


Fig. 3.2

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

.....

..... [1]

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(b) Use Fig. 3.2 to determine, for the block at time $t = 2.0\,s$, the magnitude of:

(i) the resultant force on the block

resultant force = ... N [1]

(ii) the force X.

X = ... N [1]

(c) On Fig. 3.3, sketch a graph to show the variation of force X with time t from $t = 0$ to $t = 6.0\,s$.

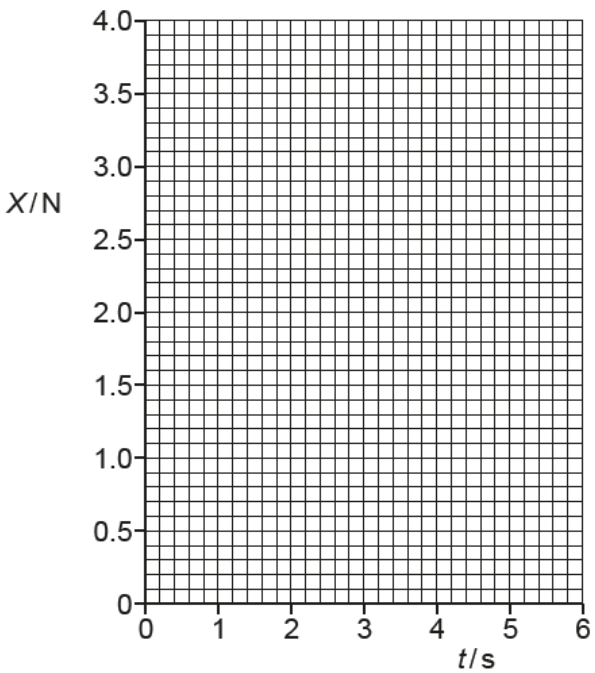


Fig. 3.3

[3]

[Total: 6]

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14. June/2023/Paper_ 9702/22/No.3

A block is pulled by a force X in a straight line along a rough horizontal surface, as shown in Fig. 3.1.

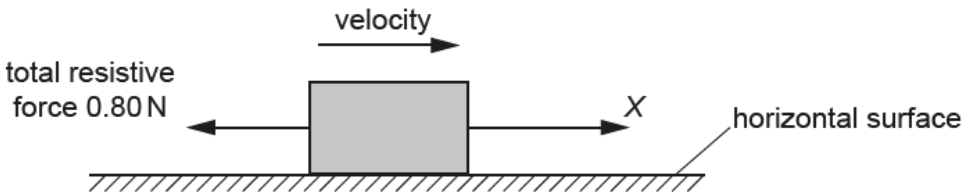


Fig. 3.1

Assume that the total resistive force opposing the motion of the block is 0.80 N at all speeds of the block.

The variation with time t of the magnitude of the force X is shown in Fig. 3.2.

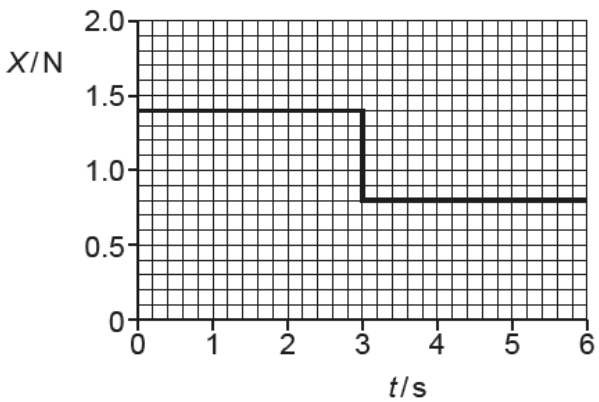


Fig. 3.2

(a) (i) Define force.

.....

..... [1]

(ii) Determine the change in momentum of the block from time $t = 0$ to time $t = 3.0$ s.

change in momentum = ... kg m s^{-1} [2]

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(b) **(i)** Describe and explain the motion of the block between time $t = 3.0\,s$ and time $t = 6.0\,s$.

.....

.....

.....

..... [2]

(ii) Force X produces a total power of 2.0 W when moving the block between time $t = 3.0\,s$ and time $t = 6.0\,s$.

Calculate the distance moved by the block during this time interval.

distance = ... m [3]

(c) The block is at rest at time $t = 0$.

On Fig. 3.3, sketch a graph to show the variation of the momentum of the block with time t from $t = 0$ to $t = 6.0\,s$.
Numerical values of momentum are not required.

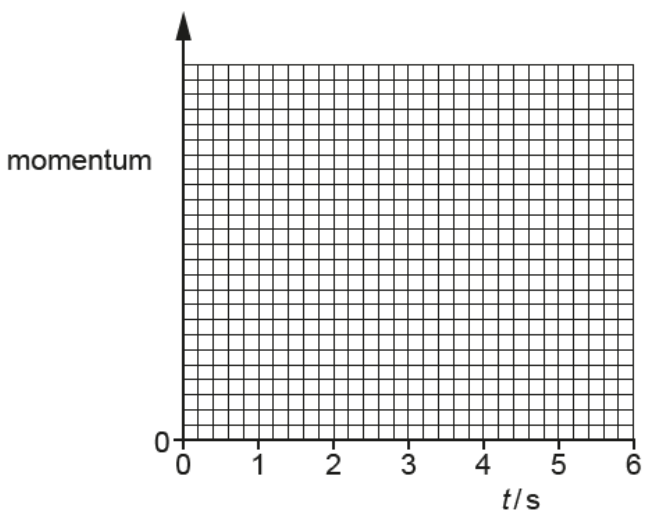


Fig. 3.3

[2]

[Total: 10]

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(a) State the principle of conservation of momentum.

.....

.....

..... [2]

(b) A firework is initially stationary. It explodes into three fragments A, B and C that move in a horizontal plane, as shown in the view from above in Fig. 3.1.

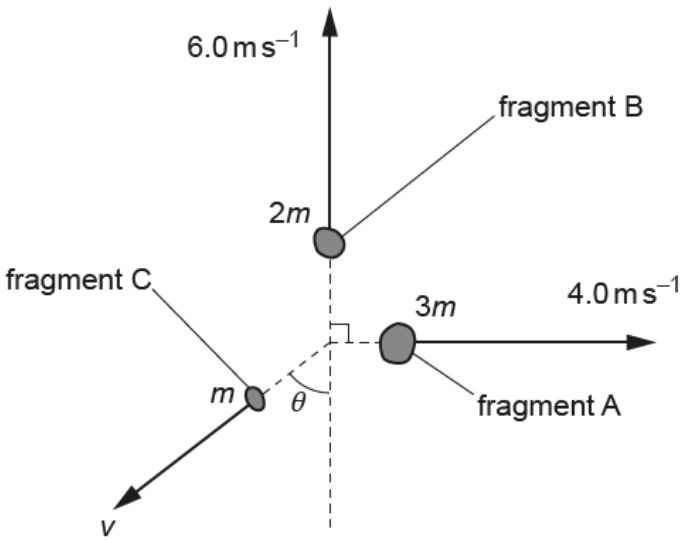


Fig. 3.1

Fragment A has a mass of $3m$ and moves away from the explosion at a speed of $4.0\,m\,s^{-1}$.

Fragment B has a mass of $2m$ and moves away from the explosion at a speed of $6.0\,m\,s^{-1}$ at right angles to the direction of A.

Fragment C has a mass of m and moves away from the explosion at a speed v and at an angle θ as shown in Fig. 3.1.

Calculate:

(i) the angle θ

$\theta =$ .....° [3]

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(ii) the speed v.

v = ... $m\,s^{-1}$ [2]

(c) The firework in **(b)** contains a chemical that has mass 5.0 g and has chemical energy per unit mass 700 $J\,kg^{-1}$. When the firework explodes, all of the chemical energy is transferred to the kinetic energy of fragments A, B and C.

(i) Show that the total chemical energy in the firework is 3.5 J.

[1]

(ii) Calculate the mass m.

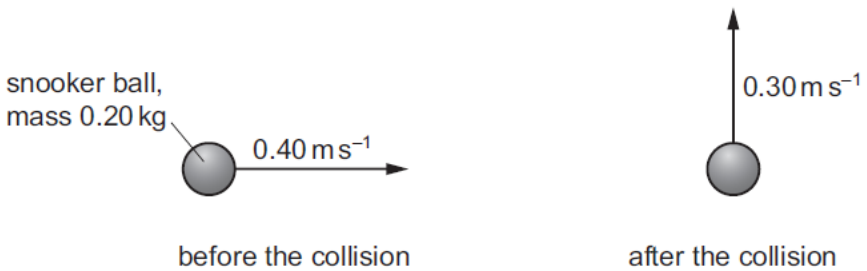
m = ... kg [3]

[Total: 11]

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16. March/2023/Paper_ 9702/12/No.4

A snooker ball of mass 0.20 kg has a collision so that its direction of movement changes by an angle of 90°, as shown.



The ball has a speed of 0.40 m s^{-1} before the collision and a speed of 0.30 m s^{-1} after the collision.

What is the **magnitude** of the change in momentum of the snooker ball?

A 0.020 kg m s^{-1}

B 0.10 kg m s^{-1}

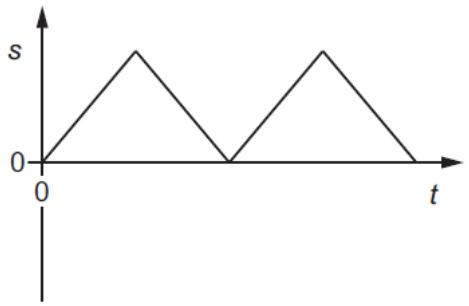
C 0.14 kg m s^{-1}

D 0.50 kg m s^{-1}

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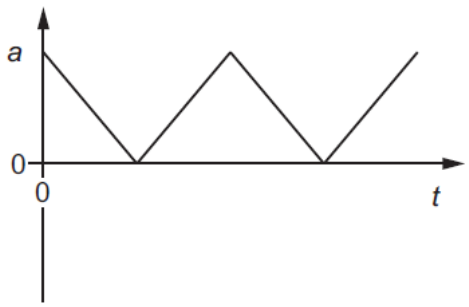
17. March/2023/Paper_ 9702/12/No.6

The graph shows the variation with time t of the displacement s of an object.

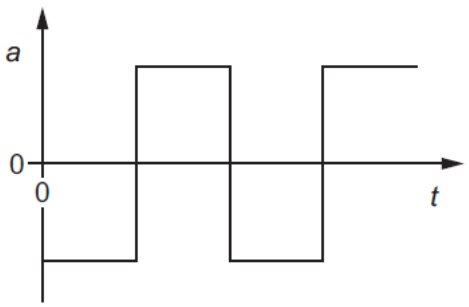


Which graph represents the variation with time t of the acceleration a of the object?

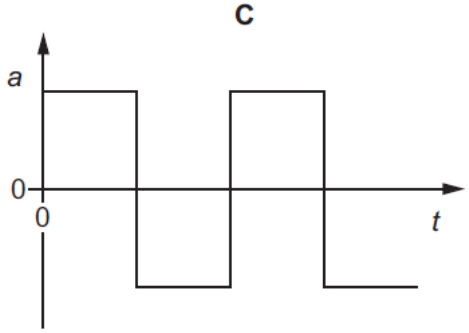
A



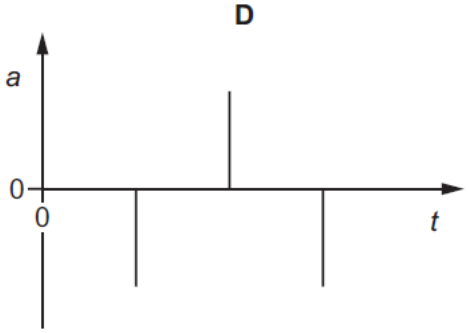
B



C



D

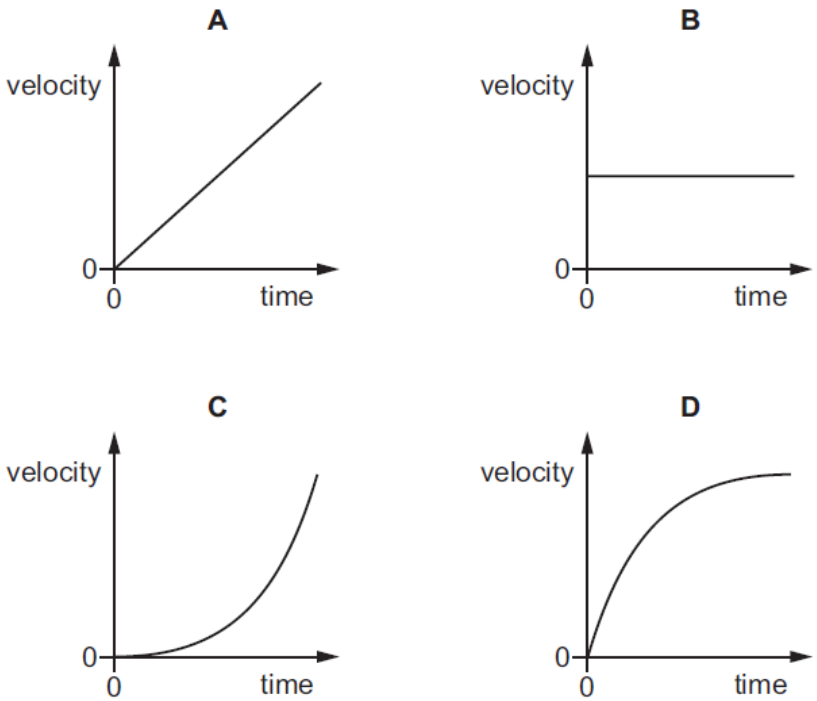


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18. March/2023/Paper_ 9702/12/No.9

The velocity–time graphs of four different objects are shown.

Which graph represents an object falling from rest through a long distance in the Earth's atmosphere?



19. March/2023/Paper_ 9702/12/No.10

Which statement about collisions is correct?

A Kinetic energy is conserved in all collisions.

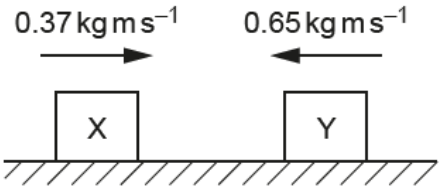
B Momentum is only conserved in perfectly elastic collisions.

C The relative speed of approach is equal to the relative speed of separation for perfectly elastic collisions.

D When two objects of different masses collide, they exert forces of different magnitudes on each other.

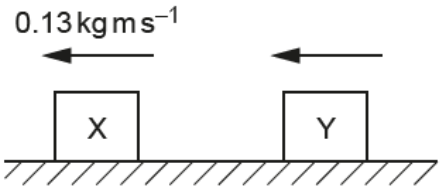
20. March/2023/Paper_ 9702/22/No.4

Two blocks slide directly towards each other along a frictionless horizontal surface, as shown in Fig. 4.1. The blocks collide and then move as shown in Fig. 4.2.



BEFORE COLLISION

Fig. 4.1



AFTER COLLISION

Fig. 4.2

Block X initially moves to the right with a momentum of $0.37\,kg\,m\,s^{-1}$. Block Y initially moves to the left with a momentum of $0.65\,kg\,m\,s^{-1}$. After the blocks collide, block X moves to the left back along its original path with a momentum of $0.13\,kg\,m\,s^{-1}$. Block Y also moves to the left after the collision.

(a) Block X has an initial kinetic energy of 0.30 J.

Calculate the mass of block X.

mass = ... kg [3]

(b) Determine the magnitude of the momentum of block Y after the collision.

momentum = ... $kg\,m\,s^{-1}$ [1]

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(c) Block X exerts an average force of 7.7 N on block Y during the collision.

Calculate the time that the blocks are in contact with each other.

time = ... s [2]

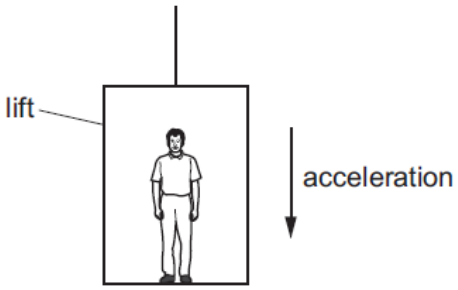
[Total: 6]

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Dynamics – 2023 Nov AS Physics 9702

1. Nov/2023/Paper_ 9702/11/No.7

A man stands in a lift that is accelerating vertically downwards, as shown.



Which statement describes the force exerted by the man on the floor?

A It is equal to the weight of the man.

B It is greater than the force exerted by the floor on the man.

C It is less than the force exerted by the floor on the man.

D It is less than the weight of the man.

2. Nov/2023/Paper_ 9702/11/No.8

A ball of mass 200 g is thrown horizontally with a speed of 20 m s^{-1} against a vertical wall.

The ball is in contact with the wall for a time of 0.10 s before rebounding back along its original path with a speed of 10 m s^{-1}.

What is the average force exerted by the wall on the ball during the collision?

A 20 N **B** 60 N **C** 20 kN **D** 60 kN

3. Nov/2023/Paper_ 9702/11/No.9

In an experiment, a metal ball is dropped into a viscous liquid. The terminal velocity of the ball in the liquid is measured.

The experiment is repeated four times. For each repeat, a change is made to one of the following.

1 the density of the metal of the ball

2 the height from which the ball is dropped

3 the density of the liquid

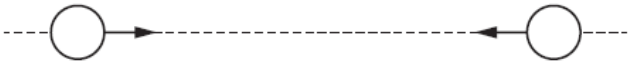
4 the depth of the liquid

Which two changes separately affect the terminal velocity of the ball in the liquid?

A 1 and 2 **B** 1 and 3 **C** 2 and 4 **D** 3 and 4

4. Nov/2023/Paper_ 9702/11/No.10

Two objects move towards each other along the same straight line.



After colliding, the two objects stick together and are stationary.

Which statement **must** be correct?

A The total kinetic energy of the two objects does not change during the collision.

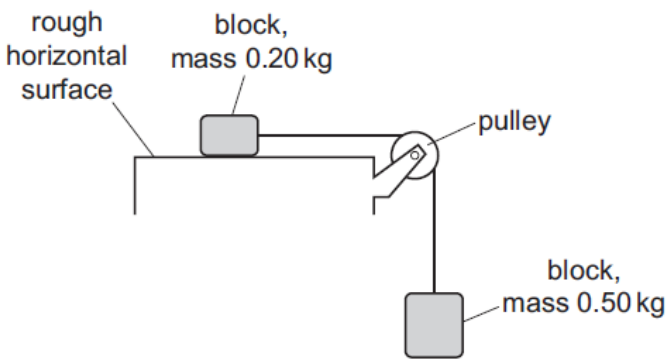
B The total momentum of the two objects before the collision is zero.

C The two objects have equal mass.

D The two objects have the same speed before the collision.

5. Nov/2023/Paper_ 9702/12/No.7

Two blocks, of mass 0.20 kg and 0.50 kg, are connected by a light inextensible string that passes over a frictionless pulley.



The blocks are initially held stationary. The block of mass 0.20 kg rests on a rough horizontal surface.

The block of mass 0.50 kg is suspended in air. Air resistance is negligible.

When the blocks are released, they have an acceleration of magnitude 2.0 m s^{-2}.

What is the magnitude of the frictional force between the block of mass 0.20 kg and the rough surface?

A 3.5 N **B** 3.9 N **C** 4.5 N **D** 6.3 N

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6. Nov/2023/Paper_ 9702/12/No.8

A resultant force causes an object to accelerate.

What is equal to the resultant force?

A the acceleration of the object per unit mass

B the change in kinetic energy of the object per unit time

C the change in momentum of the object per unit time

D the change in velocity of the object per unit time

7. Nov/2023/Paper_ 9702/12/No.9

An object falls from a stationary helicopter and reaches terminal velocity.

What happens to the acceleration of the object between leaving the helicopter and reaching terminal velocity?

A It decreases to $9.81\,\text{m s}^{-2}$.

B It decreases to zero.

C It increases to $9.81\,\text{m s}^{-2}$.

D It remains constant at $9.81\,\text{m s}^{-2}$.

8. Nov/2023/Paper_ 9702/12/No.10

Two balls, of masses m and $2m$, travelling in a vacuum with initial velocities $2v$ and v respectively, collide with each other head-on, as shown.



After the collision, the ball of mass m rebounds to the left with velocity v.

What is the loss of kinetic energy in the collision?

A $\frac{3}{4}mv^2$ **B** $\frac{3}{2}mv^2$ **C** $\frac{9}{4}mv^2$ **D** $\frac{9}{2}mv^2$

9. Nov/2023/Paper_ 9702/13/No.6

The time taken for an object to fall from rest through a certain distance on Mars is T_M. The time taken for the same object to fall from rest through the same distance on Earth is T_E. The acceleration of free fall on Mars is $3.71\,\text{m s}^{-2}$.

Assume that air resistance is negligible on both Earth and Mars.

What is the ratio $\frac{T_M}{T_E}$?

A 0.378 **B** 0.615 **C** 1.63 **D** 2.64

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10. Nov/2023/Paper_ 9702/13/No.7

Which statement about mass is correct?

A Mass has a magnitude and a direction.

B Mass resists changes in motion.

C The greater the mass of an object, the greater its acceleration when falling in a vacuum.

D The mass of an object depends on its location.

11. Nov/2023/Paper_ 9702/13/No.8

A snooker ball has a mass of 200 g. It hits the cushion of a snooker table and rebounds along its original path.

The ball arrives at the cushion with a speed of $14.0\,m\,s^{-1}$ and then leaves it with a speed of $7.0\,m\,s^{-1}$. The ball and the cushion are in contact for a time of 0.60 s.

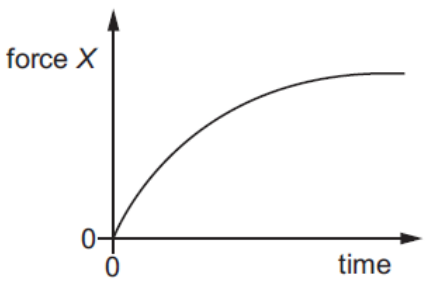
What is the average force exerted on the ball by the cushion?

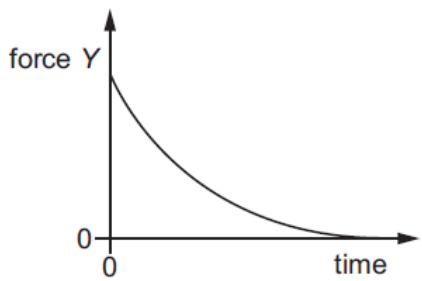
A 1.4 N **B** 2.3 N **C** 4.2 N **D** 7.0 N

12. Nov/2023/Paper_ 9702/13/No.9

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 could be forces *X* and *Y*?

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

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13. Nov/2023/Paper_ 9702/13/No.10

An object X of mass 0.30 kg is travelling in a straight line at a constant velocity of 3.0 m s^{-1} on a horizontal frictionless surface. Object X collides with a stationary object Y of mass 0.50 kg.

After the collision, X moves with a velocity of 2.0 m s^{-1} at an angle of 60° to its direction before the collision. Object Y moves with a velocity v at an angle of 41° to the direction of X before the collision, as shown.



What is the value of v?

A 0.80 m s^{-1} **B** 1.2 m s^{-1} **C** 1.6 m s^{-1} **D** 1.8 m s^{-1}

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14. Nov/2023/Paper_ 9702/21/No.3

A trolley A moves along a horizontal surface at a constant velocity towards another trolley B which is moving at a lower constant speed in the same direction. Fig. 3.1 shows the trolleys at time $t = 0$.



Fig. 3.1

Table 3.1 shows data for the trolleys.

Table 3.1

trolley	mass / kg	initial speed / m s^{-1}
A	0.25	0.48
B	0.75	0.12

The two trolleys collide elastically and then separate. Resistive forces are negligible.

Fig. 3.2 shows the variation with time t of the velocity v for trolley B.

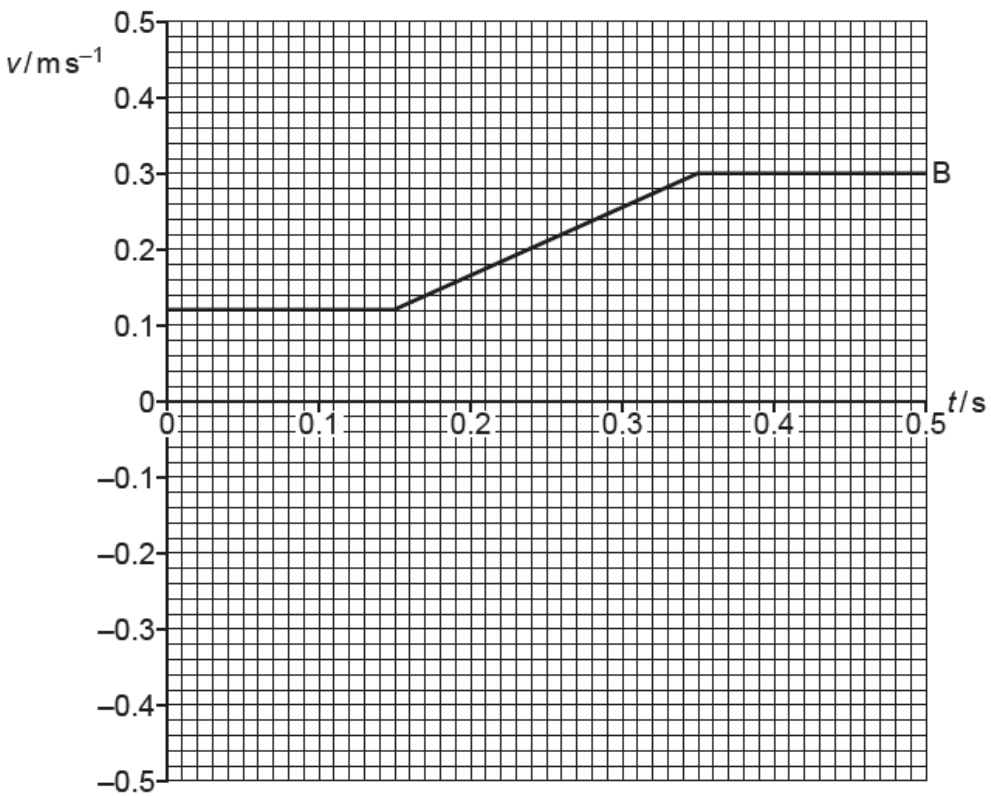


Fig. 3.2

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(a) State what is represented by the area under a velocity–time graph.

..... [1]

(b) Use Table 3.1 and Fig. 3.2 to determine:

(i) the acceleration of trolley B during the collision

acceleration of B = ... $m\,s^{-2}$ [2]

(ii) the magnitude and direction of the final velocity of trolley A.

magnitude = ... $m\,s^{-1}$

direction .....
[3]

(c) On Fig. 3.2, sketch the variation of the velocity of trolley A with time t from $t = 0$ to $t = 0.50\,s$.
[3]

[Total: 9]

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15. Nov/2023/Paper_ 9702/22/No.2(b, c)

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.

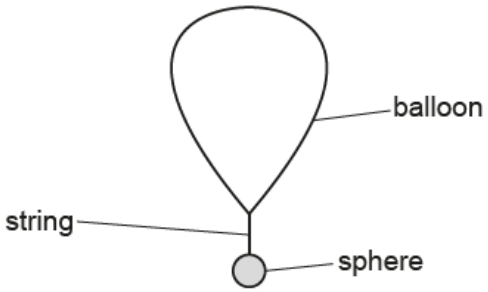


Fig. 2.1 (not to scale)

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.

(b) The string breaks, releasing the sphere.

(i) State the magnitude of the acceleration of the sphere immediately after the string breaks.

acceleration = ... $m\,s^{-2}$ [1]

(ii) State and explain the variation, if any, in the magnitude of the acceleration of the sphere when it is moving downwards **before** it reaches terminal (constant) velocity.

.....

.....

.....

.....

.....

.....

..... [3]

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(c) The sphere has a mass of 4.0 kg.

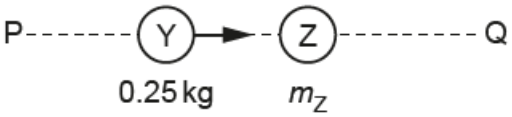
Calculate the total resistive force acting on the sphere at the instant when its acceleration is $1.9\,m\,s^{-2}$.

resistive force = ... N [2]

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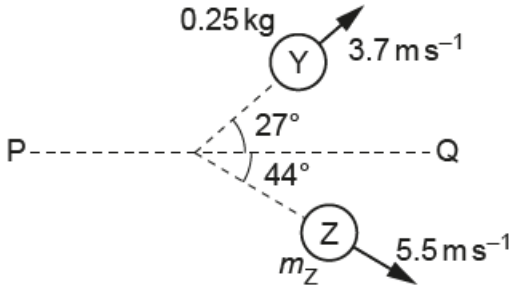
16. Nov/2023/Paper_ 9702/22/No.4

(a) A ball Y moves along a horizontal frictionless surface and collides with a ball Z, as illustrated in the views from above in Fig. 4.1 and Fig. 4.2.



BEFORE COLLISION

Fig. 4.1 (not to scale)



AFTER COLLISION

Fig. 4.2 (not to scale)

Ball Y has a mass of 0.25 kg and initially moves along a line PQ.
Ball Z has a mass m_Z and is initially stationary.

After the collision, ball Y has a final velocity of 3.7 m s^{-1} at an angle of 27° to line PQ and ball Z has a final velocity of 5.5 m s^{-1} at an angle of 44° to line PQ.

(i) Calculate the component of the final momentum of ball Y in the direction perpendicular to line PQ.

component of momentum = ... Ns [2]

(ii) By considering the component of the final momentum of each ball in the direction perpendicular to line PQ, calculate m_Z.

m_Z = ... kg [1]

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(iii) During the collision, the average force exerted on Y by Z is F_Y and the average force exerted on Z by Y is F_Z.

Compare the magnitudes and directions of F_Y and F_Z. Numerical values are not required.

magnitudes: .....

directions: .....

[2]

(b) Two blocks, A and B, move directly towards each other along a horizontal frictionless surface, as shown in the view from above in Fig. 4.3.



Fig. 4.3

The blocks collide perfectly elastically. Before the collision, block A has a speed of $4\,m\,s^{-1}$ and block B has a speed of $6\,m\,s^{-1}$. After the collision, block B moves back along its original path with a speed of $2\,m\,s^{-1}$.

Calculate the speed of block A after the collision.

speed = ... $m\,s^{-1}$ [1]

[Total: 6]

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(c) At a certain time, the airship in **(b)** is stationary. The thrust force exerted by a fan on the airship is 2800 N.

To produce this force, a mass of 64 kg of air is propelled through the blades of the fan in a time of 0.50 s. Assume that this air is initially stationary at the entrance to the fan.

Calculate:

(i) the change in momentum Δp of the air propelled through the fan blades in this time

Δp = ... kg m s^{-1} [2]

(ii) the speed of the air as it leaves the fan

speed = ... m s^{-1} [2]

(iii) the total kinetic energy of this air due to its movement through the fan.

kinetic energy = ... J [2]

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