

PHYSICS



EXAM QUESTION PACK

5 WORK, ENERGY AND POWER

SCORE

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PERCENTAGE

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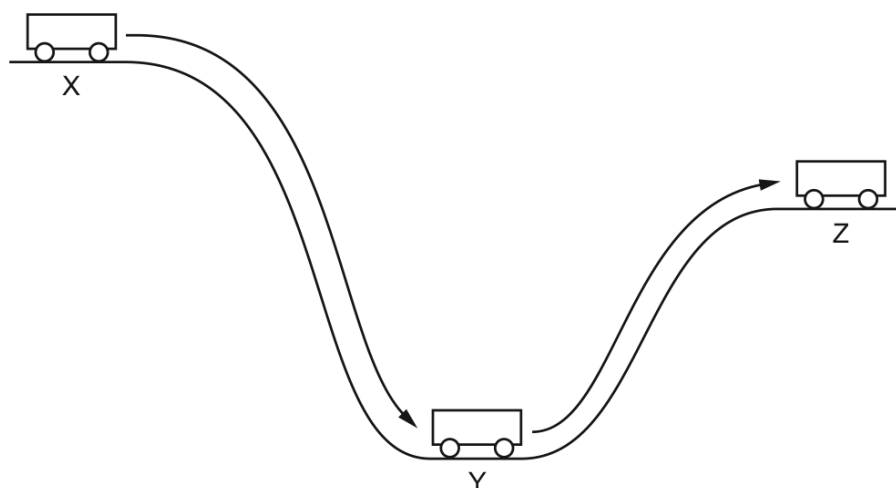
Chapter 6

Work, energy and power

6.1 Energy conversion and conservation

499. 9702_s20_qp_13 Q: 16

A trolley starts from rest at X. It rolls down to Y and eventually comes to rest at Z.



Which row is a possible summary of the energy changes during this process?

	X to Y	Y to Z
A	PE $\rightarrow$ KE	KE $\rightarrow$ PE
B	PE $\rightarrow$ KE	KE $\rightarrow$ PE + heat
C	PE $\rightarrow$ KE + heat	KE $\rightarrow$ PE
D	PE $\rightarrow$ KE + heat	KE $\rightarrow$ PE + heat

key

PE = potential energy

KE = kinetic energy

500. 9702_m19_qp_12 Q: 15

Which statement best represents the principle of conservation of energy?

- A** Energy cannot be used faster than it is created.
 - B** The supply of energy is limited, so energy must be conserved.
 - C** The total energy in a closed system is constant.
 - D** The total energy input to a system is equal to the useful energy output.
-

501. 9702_s19_qp_13 Q: 15

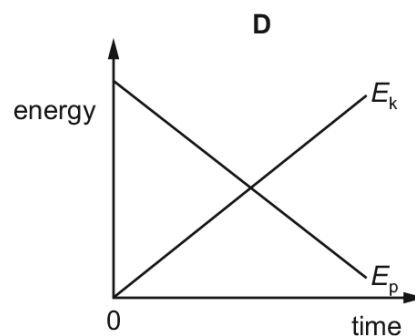
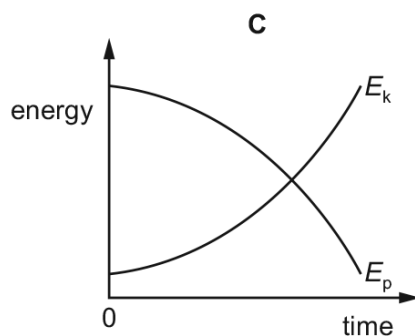
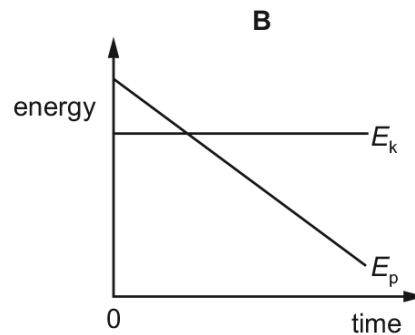
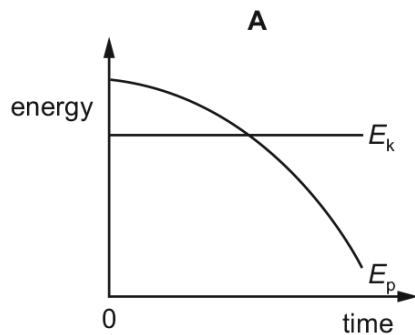
Which statement about the principle of conservation of energy is correct?

- A** Energy conversion helps to conserve energy sources.
 - B** Energy is conserved only in systems with an efficiency of 100%.
 - C** The supply of energy is limited so energy should be conserved.
 - D** The total amount of energy in a closed system is constant.
-

502. 9702_w19_qp_13 Q: 16

A steel ball is falling at constant speed in oil.

Which graph shows the variation with time of the gravitational potential energy E_p and the kinetic energy E_k of the ball?



503. 9702_w18_qp_11 Q: 14

A rocket is fired upwards.

As it accelerates upwards after leaving the launch pad, which forms of energy are changing?

- A** chemical energy, gravitational potential energy and kinetic energy
- B** chemical energy and gravitational potential energy only
- C** chemical energy and kinetic energy only
- D** gravitational potential energy and kinetic energy only

504. 9702_w18_qp_12 Q: 15

A bungee jumper on a platform over a river is attached to an elastic rope that is 20 m long when unstretched. He falls towards the river and his lowest point is 30 m below the platform.

The initial gravitational potential energy of the jumper is transferred to other forms during the jump.

Which other forms of energy do the jumper and rope have when the jumper has fallen half-way and when he is at the lowest point of his jump?

	half-way	lowest point
A	kinetic energy and elastic potential energy	kinetic energy and elastic potential energy
B	kinetic energy and elastic potential energy	elastic potential energy only
C	kinetic energy only	kinetic energy and elastic potential energy
D	kinetic energy only	elastic potential energy only

505. 9702_s17_qp_11 Q: 15

A man climbs slowly at a steady speed to the top of a ladder.

What is the **main** energy transfer taking place for the man as he climbs?

- A** chemical potential to gravitational potential
- B** chemical potential to kinetic
- C** kinetic to gravitational potential
- D** thermal (heat) to kinetic

506. 9702_w17_qp_13 Q: 15

A ball is thrown vertically upwards. Air resistance is negligible.

Which statement is correct?

- A By the principle of conservation of energy, the total energy of the ball is constant throughout its motion.
 - B By the principle of conservation of momentum, the momentum of the ball is constant throughout its motion.
 - C The kinetic energy of the ball is greatest at the greatest height attained.
 - D The potential energy of the ball increases at a constant rate during its ascent.
-

507. 9702_s16_qp_12 Q: 16

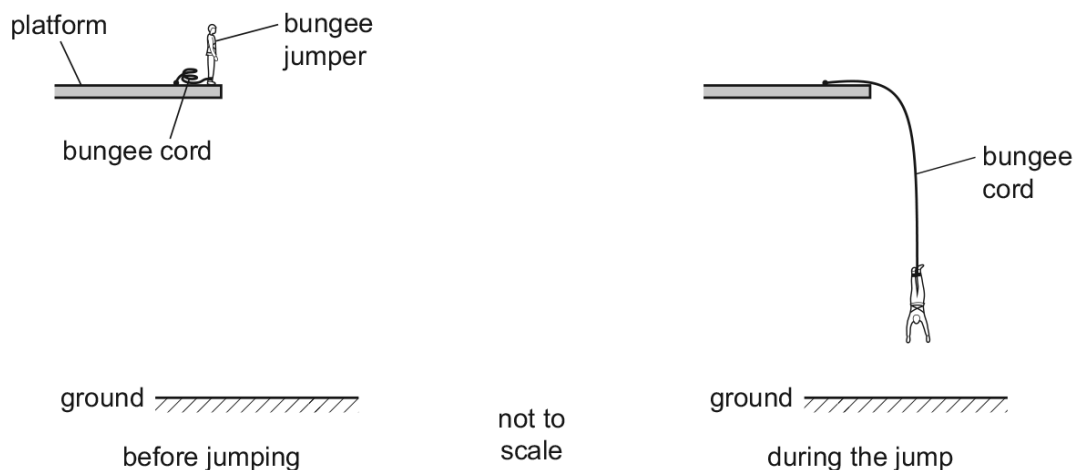
A parachutist is falling at constant (terminal) velocity.

Which statement is **not** correct?

- A Gravitational potential energy is converted into kinetic energy of the air.
 - B Gravitational potential energy is converted into kinetic energy of the parachutist.
 - C Gravitational potential energy is converted into thermal energy of the air.
 - D Gravitational potential energy is converted into thermal energy of the parachutist.
-

508. 9702_s16_qp_13 Q: 16

A bungee jumper jumps from a platform and is decelerated by an elastic bungee cord, as shown.



When the jumper makes the jump, his initial gravitational potential energy is converted into his kinetic energy and into elastic potential energy in the cord.

At which part of the jump are all three types of energy non-zero?

- A on the platform before the jump
- B on the way down before the cord has started to extend
- C on the way down as he decelerates
- D at the bottom of the jump when he is stationary

6.2 Work and efficiency

509. 9702_m20_qp_12 Q: 14

A cylinder contains a volume of 0.012 m^3 of gas at a pressure of $1.0 \times 10^5 \text{ Pa}$.

400 J of work is done **on** this gas, with its pressure remaining constant throughout.

What is the final volume of the gas?

- A 0.0040 m^3 B 0.0080 m^3 C 0.016 m^3 D 0.020 m^3
-

510. 9702_m20_qp_12 Q: 16

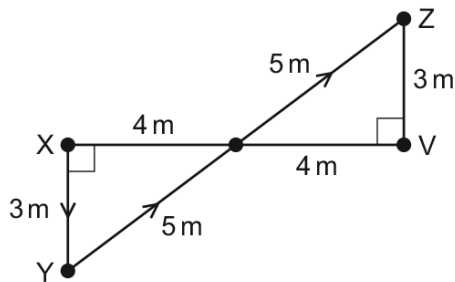
A sledge of mass 50 kg sits on a snowy surface. It is pulled horizontally for 10 m against a frictional force of 200 N, then it is pulled horizontally across ice for 10 m. There is no friction between the ice and the sledge. It is lifted up vertically by 1 m and finally carried back at a constant speed to where it started.

During which stage of its journey is most work done on the sledge?

- A being carried back 20 m at constant speed
- B being lifted up 1 m
- C being pulled 10 m across ice
- D being pulled 10 m across snow

511. 9702_m20_qp_12 Q: 17

An object is moved in a vertical plane from X to Y, and then from Y to Z, as shown in the diagram.



The distances between various points are indicated on the diagram.

Lines XY and VZ are vertical.

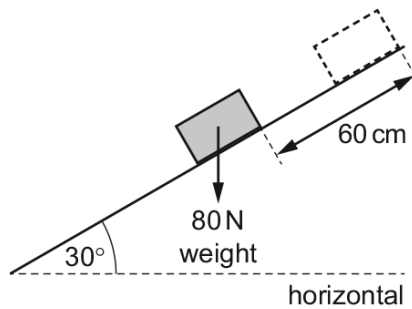
The object weighs 20 N.

How much gravitational potential energy does the object gain by moving from X to Z?

- A 60 J
- B 120 J
- C 140 J
- D 260 J

512. 9702_s20_qp_11 Q: 17

A block of weight 80 N is pushed a distance of 60 cm up a slope inclined at 30° to the horizontal. There is a frictional force of 25 N between the block and the surface of the slope.

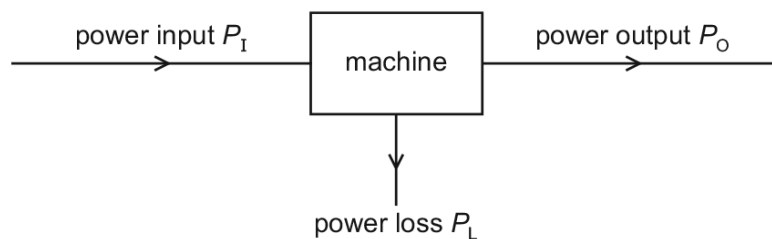


What is the work W_g done against the gravitational force and the work W_f done against the frictional force?

	W_g/J	W_f/J
A	24	7.5
B	24	15
C	48	7.5
D	48	15

513. 9702_s20_qp_11 Q: 19

Power is transferred through a machine as shown.



What is the efficiency of the machine?

- A** $\frac{P_I}{P_O + P_L}$ **B** $\frac{P_L}{P_I}$ **C** $\frac{P_L}{P_O}$ **D** $\frac{P_O}{P_I}$

514. 9702_s20_qp_12 Q: 14

During an interval of time, fuel supplies energy X to a car.

Some of this energy is converted into kinetic energy as the car accelerates.

The rest of the energy Y is lost as thermal energy.

What is the efficiency of the car?

- A** $\frac{X}{X-Y}$ **B** $\frac{Y}{X-Y}$ **C** $\frac{X-Y}{X}$ **D** $\frac{X-Y}{Y}$
-

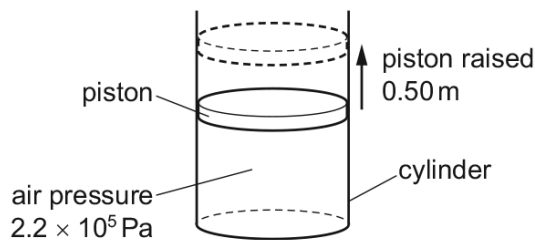
515. 9702_s20_qp_12 Q: 15

In which situation is work done on an object?

- A** The object slides with a constant velocity along a horizontal frictionless surface in a vacuum.
B A person holds the object at arm's length and at a fixed height above the ground.
C A person pushes the object up a frictionless ramp.
D The stationary object floats partially submerged in water.
-

516. 9702_s20_qp_13 Q: 17

A cylinder is heated, causing the air inside to expand at a constant pressure of $2.2 \times 10^5 \text{ Pa}$.



The expansion of the air causes the piston to rise through a vertical distance of 0.50 m, doing 11 kJ of work. Frictional forces are negligible.

What is the cross-sectional area of the piston?

- A** $1.0 \times 10^{-4} \text{ m}^2$
B $2.5 \times 10^{-2} \text{ m}^2$
C $5.0 \times 10^{-2} \text{ m}^2$
D $1.0 \times 10^{-1} \text{ m}^2$
-

517. 9702_s19_qp_11 Q: 8

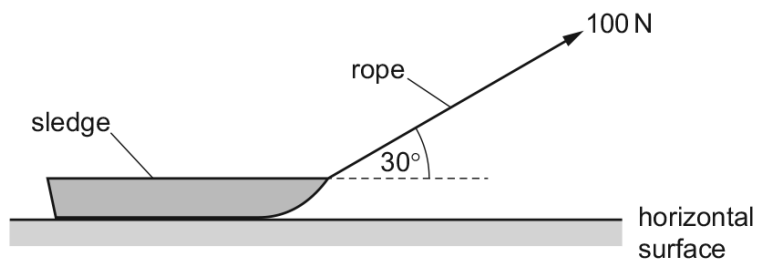
A positive charge of $2.6 \times 10^{-8} \text{ C}$ is in a uniform electric field of field strength $300\,000 \text{ V m}^{-1}$.

How much work must be done on the charge in order to move it a distance of 4.0 mm in the opposite direction to the direction of the field?

- A** $3.1 \times 10^{-5} \text{ J}$
 - B** $2.0 \times 10^{-3} \text{ J}$
 - C** $3.1 \times 10^{-2} \text{ J}$
 - D** 2.0 J
-

518. 9702_s19_qp_11 Q: 17

A rope is attached to a sledge and a boy uses the rope to pull the sledge along a horizontal surface with a constant velocity. The tension in the rope is 100 N and the rope is held at 30° to the horizontal.

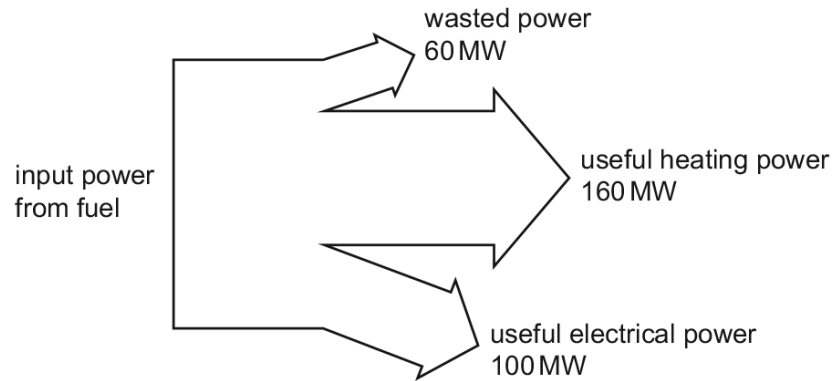


How much work does the boy do on the sledge when he pulls it a distance of 5.0 m along the surface?

- A** 250 J
 - B** 290 J
 - C** 430 J
 - D** 500 J
-

519. 9702_s19_qp_12 Q: 17

A combined heat and power (CHP) station generates electrical power and useful heat. The diagram shows the input and output powers for a CHP station.



What is the efficiency of the CHP station for producing useful power?

- A** 31% **B** 38% **C** 50% **D** 81%

520. 9702_w19_qp_11 Q: 15

An electric motor produces 120 W of useful mechanical output power. The efficiency of the motor is 60%.

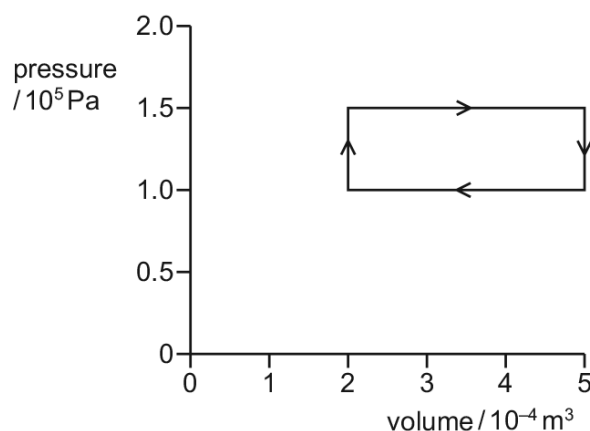
Which row is correct?

	electrical power input / W	waste heat power output / W
A	72	48
B	192	72
C	200	72
D	200	80

521. 9702_w19_qp_11 Q: 16

A fixed amount of a gas undergoes a series of changes to its pressure and volume.

In two of the changes, no work is done by or on the gas. In one change work is done by the gas on its surroundings. In another change work is done on the gas by its surroundings.

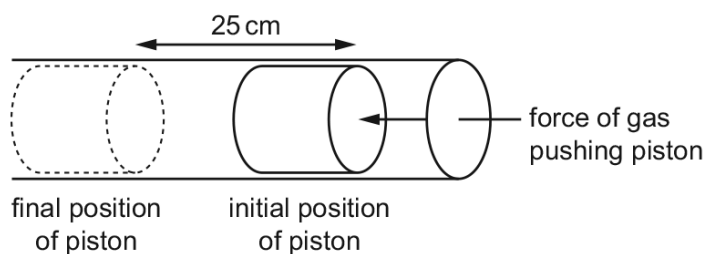


During the change when work is done on the gas by its surroundings, how much work is done on the gas?

- A** 15 J **B** 25 J **C** 30 J **D** 45 J

522. 9702_w19_qp_12 Q: 14

The gas in an engine does work on a piston of cross-sectional area 80 cm^2 . The pressure on the piston has a constant value of $4.6 \times 10^5 \text{ Pa}$.

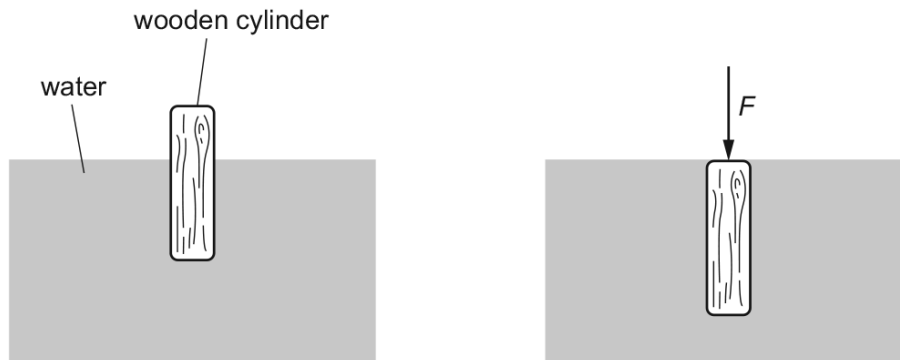


How much work is done by the gas on the piston when it moves through a distance of 25 cm?

- A** $9.2 \times 10^2 \text{ J}$ **B** $9.2 \times 10^4 \text{ J}$ **C** $9.2 \times 10^6 \text{ J}$ **D** $9.2 \times 10^8 \text{ J}$

523. 9702_w19_qp_12 Q: 16

A wooden cylinder floats partially submerged in a bath of water. A force F is applied to the cylinder until it is just fully submerged.



Which statement is **not** correct?

- A** Some of the water gains gravitational potential energy.
- B** The cylinder loses gravitational potential energy.
- C** Work is done by force F on the cylinder.
- D** Work is done by the upthrust on the cylinder.

524. 9702_w19_qp_13 Q: 15

A piston in a gas supply pump has an area of 500 cm^2 and it moves a distance of 30 cm.

The pump moves the gas against a fixed pressure of 4000 Pa .

How much work is done by the piston?

- A** 60 J **B** $6.0 \times 10^3 \text{ J}$ **C** $6.0 \times 10^5 \text{ J}$ **D** $6.0 \times 10^7 \text{ J}$

525. 9702_w19_qp_13 Q: 18

Initially, four identical uniform blocks, each of mass m and thickness h , are spread on a table.



The acceleration of free fall is g .

How much work is done on the blocks in stacking them on top of one another?

- A** $3mgh$ **B** $6mgh$ **C** $8mgh$ **D** $10mgh$

526. 9702_m18_qp_12 Q: 15

An old-fashioned 60 W lamp converts 95% of its energy supply into heat. A 4.0 W modern lamp has the same power output of light as the old-fashioned lamp.

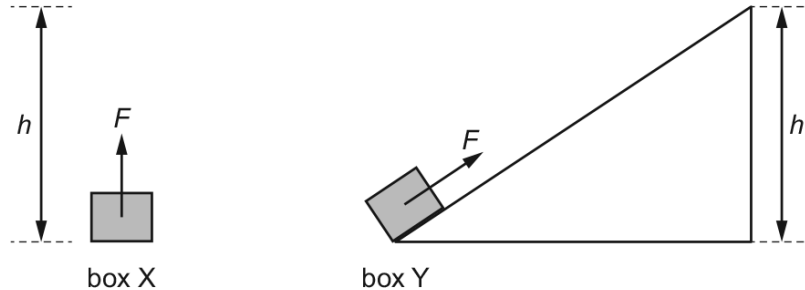
What is the efficiency of the modern lamp?

- A** 5.0% **B** 6.7% **C** 75% **D** 95%

527. 9702_m18_qp_12 Q: 18

Two boxes X and Y have the same mass. Box X is lifted vertically through a height h by a force of magnitude F .

Box Y is pulled along a slope by a force of the same magnitude to reach the same height, as shown.

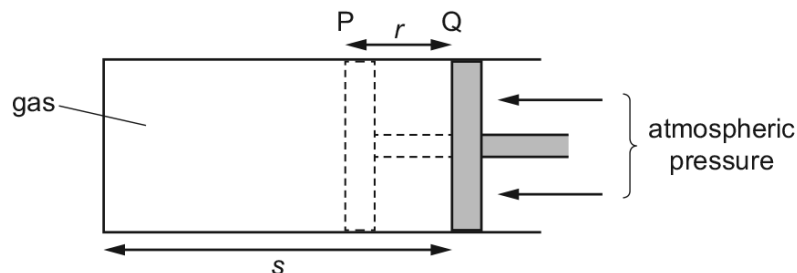


Which statement is correct?

- A** Both boxes gain the same amount of gravitational potential energy and the same amount of work is done by the two forces.
 - B** Both boxes gain the same amount of gravitational potential energy but more work is done by the force acting on box Y than by the force acting on box X.
 - C** Box Y gains less gravitational potential energy than box X because the weight of box Y is less than the weight of box X.
 - D** Box Y gains more gravitational potential energy than box X as more work is done by the force acting on box Y than by the force acting on box X.
-

528. 9702_s18_qp_13 Q: 14

Gas is trapped inside a cylinder by a piston of cross-sectional area A . The piston is **not** frictionless.



The gas is heated and this causes it to expand, pushing back the piston through distance r from position P to position Q. The length of the gas column is then s .

Which expression represents the amount of work done by the gas against the atmosphere during this expansion?

- A (atmospheric pressure) $\times Ar$
- B (atmospheric pressure) $\times As$
- C (pressure inside the gas) $\times Ar$
- D (pressure inside the gas) $\times As$

529. 9702_s18_qp_13 Q: 15

Water from a reservoir is fed to the turbine of a hydroelectric system at a rate of 510 kg s^{-1} . The reservoir is 280 m above the level of the turbine.

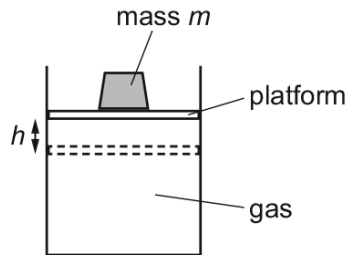
The electrical output from the generator driven by the turbine is a current of 205 A at a potential difference of 5800 V.

What is the efficiency of the system?

- A 8.3% B 12% C 83% D 85%

530. 9702_w18_qp_11 Q: 15

A mass m is on top of a platform that is supported by gas in a cylinder of cross-sectional area A , as shown.



The platform has negligible mass and can move freely up and down.

The gas is heated and expands so that the mass is raised through a height h . Atmospheric pressure is p .

What is the ratio $\frac{\text{gain in gravitational potential energy of the mass}}{\text{work done by the gas}}$?

- A** $\frac{mg}{pA}$
 B $\frac{mg}{mg + pA}$
 C $\frac{pA}{mg}$
 D $\frac{mg - pA}{mg}$

531. 9702_w18_qp_12 Q: 16

A cylinder contains a fixed mass of gas. The gas, at a constant pressure of $1.3 \times 10^5 \text{ Pa}$, expands from a volume of 900 cm^3 to a volume of 1100 cm^3 .

What is the work done by the gas during this expansion?

- A** 26 J
 B 130 J
 C 2600 J
 D 13 000 J

532. 9702_w18_qp_13 Q: 15

Which statement about energy is **not** correct?

- A** Energy is never lost but it may be transferred between different forms.
B In an inelastic collision, the total energy is constant.
C The efficiency of a system is the ratio of the useful energy output to the total energy input.
D When a machine does work, friction reduces the total energy.

533. 9702_w18_qp_13 Q: 17

On a planet, a gravitational force F acts on a mass of 6.0 kg. The mass is moved by force F a distance of 30 m in the direction of the gravitational field. The work done by the field is 450 J.

What is the force F on the mass and what is the acceleration of free fall g on the planet?

	F/N	g/ms^{-2}
A	0.067	0.011
B	0.067	0.40
C	15	2.5
D	15	90

534. 9702_m17_qp_12 Q: 16

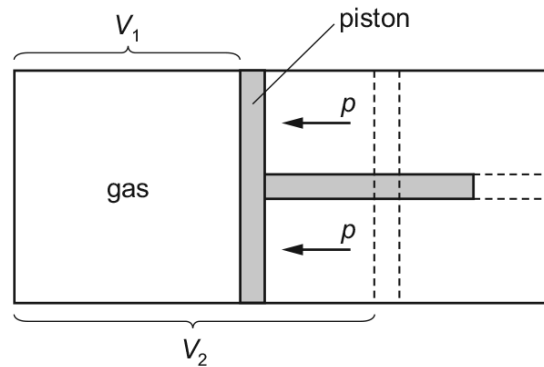
The total energy input E_{in} in a process is partly transferred to useful energy output U and partly transferred to energy that is wasted W .

What is the efficiency of the process?

- A** $\frac{U}{E_{\text{in}}} \times 100\%$
- B** $\frac{W}{E_{\text{in}}} \times 100\%$
- C** $\frac{U}{W} \times 100\%$
- D** $\frac{U+W}{E_{\text{in}}} \times 100\%$

535. 9702_m17_qp_12 Q: 17

A gas is enclosed inside a cylinder which is fitted with a frictionless piston.



Initially, the gas has a volume V_1 and is in equilibrium with the external pressure p . The gas is then heated slowly so that it expands at constant pressure, pushing the piston back until the volume of the gas has increased to V_2 .

How much work is done by the gas during this expansion?

- A** $p(V_2 - V_1)$ **B** $\frac{1}{2}p(V_2 - V_1)$ **C** $p(V_2 + V_1)$ **D** $\frac{1}{2}p(V_2 + V_1)$

536. 9702_s17_qp_11 Q: 16

During an interval of time, fuel supplies energy X to a car.

Some of this energy is converted into kinetic energy as the car accelerates.

The rest of the energy Y is lost as thermal energy.

What is the efficiency of the car?

- A** $\frac{X}{X-Y}$ **B** $\frac{Y}{X-Y}$ **C** $\frac{X-Y}{X}$ **D** $\frac{X-Y}{Y}$

537. 9702_s17_qp_11 Q: 17

A railway engine accelerates a train of total mass 800 tonnes (1 tonne = 1000 kg) from rest to a speed of 50 m s^{-1} .

How much useful work must be done on the train to reach this speed?

- A** $1.0 \times 10^6 \text{ J}$ **B** $2.0 \times 10^6 \text{ J}$ **C** $1.0 \times 10^9 \text{ J}$ **D** $2.0 \times 10^9 \text{ J}$

538. 9702_s17_qp_12 Q: 17

A railway engine accelerates a train of total mass 1200 tonnes (1 tonne = 1000 kg) from rest to a speed of 75 m s^{-1} .

How much useful work must be done on the train to reach this speed?

- A** $3.4 \times 10^6 \text{ J}$ **B** $6.8 \times 10^6 \text{ J}$ **C** $3.4 \times 10^9 \text{ J}$ **D** $6.8 \times 10^9 \text{ J}$

539. 9702_s17_qp_13 Q: 14

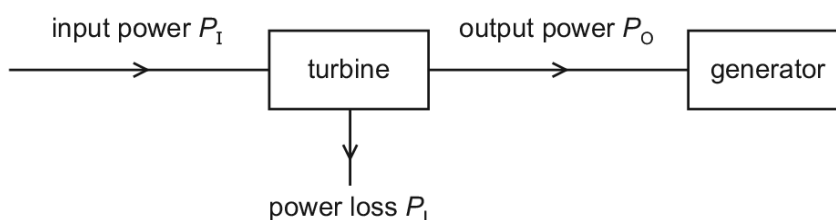
The first column in the table gives four examples of work being done. The second column gives more detail of the action.

Which row is **not** correct?

	example	detail
A	a girl dives from a diving board into a swimming pool	work is done by the girl against the gravitational field as she falls
B	a man pushes a car along a level road	work is done by the man against friction
C	an electron is accelerated towards a positively charged plate	work is done on the electron by the electric field of the plate
D	a piston is pushed outwards as a gas expands	work is done on the atmosphere by the gas

540. 9702_s17_qp_13 Q: 15

A steam turbine is used to drive a generator. The input power to the turbine is P_I and the output power is P_O . The power loss in the turbine is P_L , as shown below.

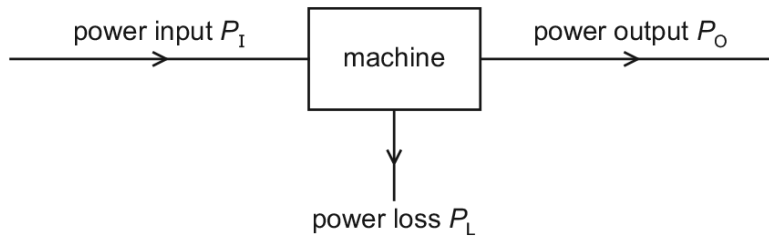


What is the efficiency of the turbine?

- A** $\frac{P_L}{P_O}$ **B** $\frac{P_I}{P_O}$ **C** $\frac{P_L}{P_I}$ **D** $\frac{P_O}{P_I}$

541. 9702_w17_qp_11 Q: 16

Power is transferred through a machine as shown.



What is the efficiency of the machine?

- A $\frac{P_I}{P_O + P_L}$ B $\frac{P_L}{P_I}$ C $\frac{P_L}{P_O}$ D $\frac{P_O}{P_I}$

542. 9702_w17_qp_11 Q: 17

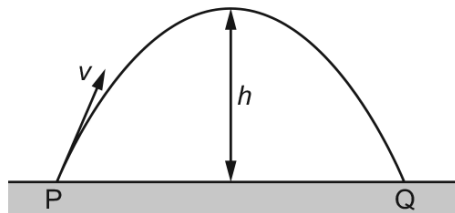
A piston in a gas supply pump has an area of 400 cm^2 . The pump moves the gas against a fixed pressure of 3000 Pa .

During part of its stroke, the piston moves a distance of 25 cm in one direction. How much work is done by the piston during this movement?

- A 30 J B $3.0 \times 10^3 \text{ J}$ C $3.0 \times 10^5 \text{ J}$ D $3.0 \times 10^7 \text{ J}$

543. 9702_w17_qp_12 Q: 16

A ball of mass m is thrown up to height h in air with an initial velocity v , as shown.



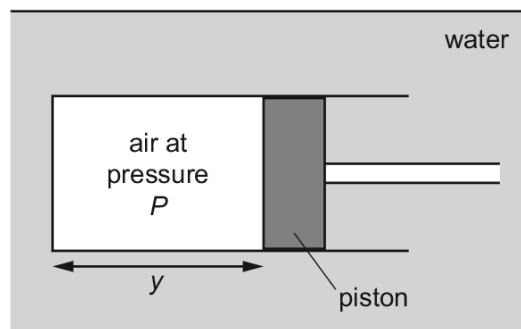
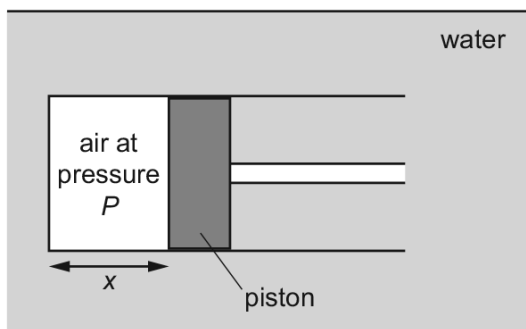
Air resistance is negligible. The acceleration of free fall is g .

What is the **total** work done by the gravitational force on the ball during its flight from P to Q?

- A zero B $\frac{1}{2}mv^2$ C mgh D $2mgh$

544. 9702_w17_qp_13 Q: 17

A horizontal cylinder of cross-sectional area A is fitted with a frictionless piston and contains air at pressure P . It is immersed in hot water and the length of the air column increases from x to y . The pressure P is constant.



Which equation represents the work done by the trapped air during this process?

- A** PAy **B** $-PAy$ **C** $PA(y - x)$ **D** $-PA(y - x)$

545. 9702_m16_qp_12 Q: 17

The pump of a water pumping system uses 2.0 kW of electrical power when raising water. The pumping system lifts 16 kg of water per second through a vertical height of 7.0 m.

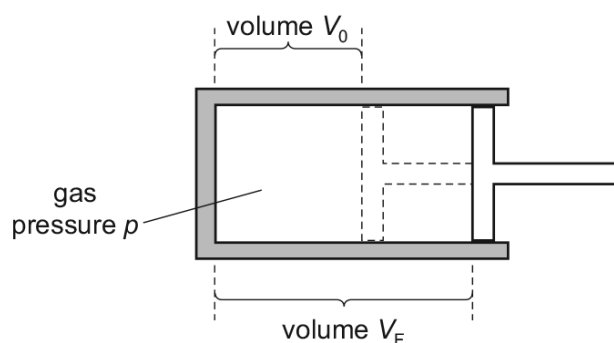
What is the efficiency of the pumping system?

- A** 1.8% **B** 5.6% **C** 22% **D** 55%

546. 9702_s16_qp_11 Q: 16

Some gas in a cylinder is supplied with thermal energy q .

The gas does useful work in expanding at constant pressure p from volume V_0 to volume V_F , as shown.

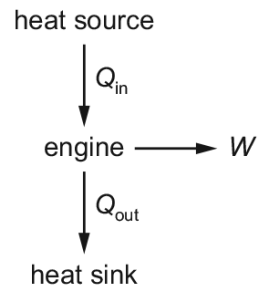


Which expression gives the efficiency of this change?

- A** $\frac{pV_0}{q}$ **B** $\frac{V_F}{V_0q}$ **C** $\frac{p(V_F - V_0)}{q}$ **D** $\frac{(V_F - V_0)}{V_0q}$

547. 9702_w16_qp_11 Q: 18

An engine transforms thermal energy into mechanical work. The engine takes in thermal energy Q_{in} from a heat source and gives out thermal energy Q_{out} to a heat sink, producing useful work W .



What is the efficiency of this engine?

- A** $\frac{W}{Q_{\text{in}} + Q_{\text{out}}}$ **B** $\frac{W}{Q_{\text{in}} - Q_{\text{out}}}$ **C** $\frac{W}{Q_{\text{in}}}$ **D** $\frac{W}{Q_{\text{out}}}$

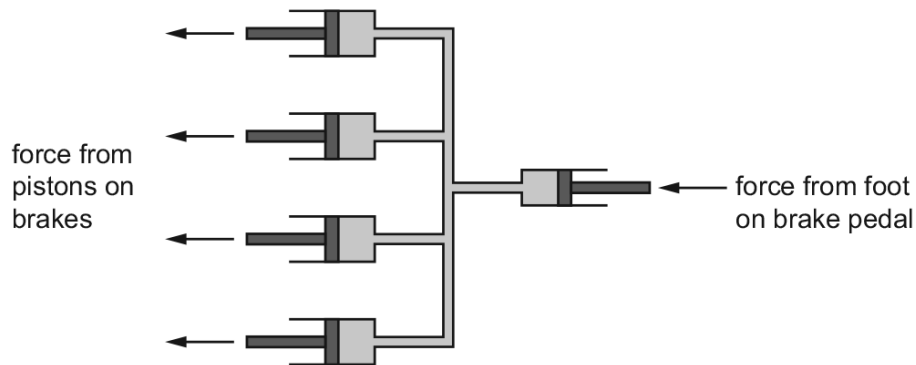
548. 9702_w16_qp_11 Q: 20

Which condition must apply for the work done by an expanding gas to be $p\Delta V$, where p is the pressure of the gas and ΔV is its change in volume?

- A** No thermal energy must be supplied to the gas.
B The expansion must be at a constant rate.
C The pressure must be constant.
D The temperature of the gas must be constant.

549. 9702_w16_qp_12 Q: 16

The diagram shows the brake system of a car.



The pipes are filled with incompressible liquid. When a force is applied to the brake pedal, the pressure in the liquid increases and applies a force to each of the four wheels.

The area of the piston connected to the brake pedal is 8 cm^2 .

The area of each piston connected to the brakes is 12 cm^2 .

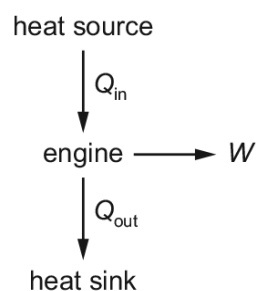
A force of 800 N is applied by the foot to the brake pedal.

What is the force applied to each brake?

- A** 300 N **B** 530 N **C** 1200 N **D** 4800 N

550. 9702_w16_qp_13 Q: 18

An engine transforms thermal energy into mechanical work. The engine takes in thermal energy Q_{in} from a heat source and gives out thermal energy Q_{out} to a heat sink, producing useful work W .



What is the efficiency of this engine?

- A** $\frac{W}{Q_{\text{in}} + Q_{\text{out}}}$ **B** $\frac{W}{Q_{\text{in}} - Q_{\text{out}}}$ **C** $\frac{W}{Q_{\text{in}}}$ **D** $\frac{W}{Q_{\text{out}}}$

551. 9702_w16_qp_13 Q: 20

Which condition must apply for the work done by an expanding gas to be $p\Delta V$, where p is the pressure of the gas and ΔV is its change in volume?

- A** No thermal energy must be supplied to the gas.
 - B** The expansion must be at a constant rate.
 - C** The pressure must be constant.
 - D** The temperature of the gas must be constant.
-

552. 9702_s15_qp_11 Q: 16

A team of nine dogs can pull a sledge with a combined force of 800 N at a speed of 1.5 m s^{-1} for 360 minutes.

What is the average work done by each dog during this time?

- A** $4.8 \times 10^4 \text{ J}$ **B** $4.3 \times 10^5 \text{ J}$ **C** $2.9 \times 10^6 \text{ J}$ **D** $2.6 \times 10^7 \text{ J}$
-

553. 9702_s15_qp_12 Q: 18

Water from a reservoir is fed to the turbine of a hydroelectric system at a rate of 500 kg s^{-1} . The reservoir is 300 m above the level of the turbine.

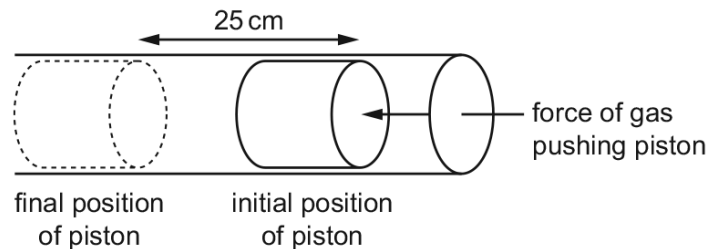
The electrical output from the generator driven by the turbine is 200 A at a potential difference of 6000 V.

What is the efficiency of the system?

- A** 8.0% **B** 8.2% **C** 80% **D** 82%
-

554. 9702_s15_qp_13 Q: 17

The gas in an engine does work on a piston of cross-sectional area 80 cm^2 . The pressure on the piston has a constant value of $4.6 \times 10^5 \text{ Pa}$.



How much work is done by the gas on the piston when it moves through a distance of 25 cm?

- A** $9.2 \times 10^2 \text{ J}$ **B** $9.2 \times 10^4 \text{ J}$ **C** $9.2 \times 10^6 \text{ J}$ **D** $9.2 \times 10^8 \text{ J}$
-

6.3 Potential energy and kinetic energy

555. 9702_m20_qp_12 Q: 15

A ball is thrown vertically upwards from the surface of the Earth.

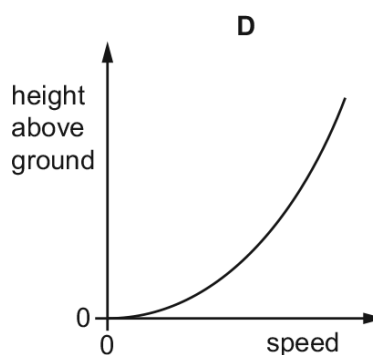
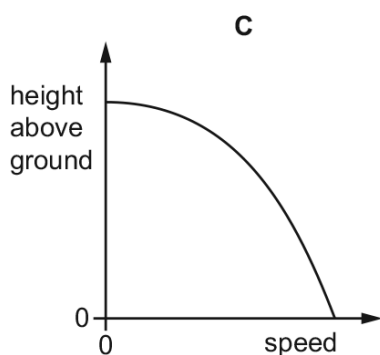
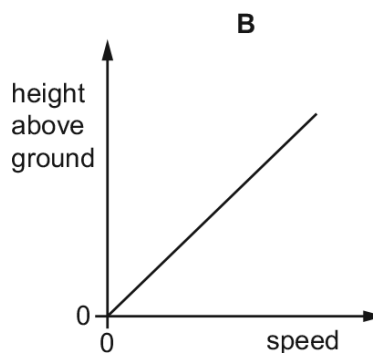
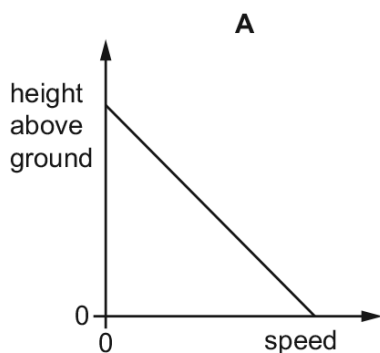
Which statement describes the energy of the ball as it rises through the air?

- A** The kinetic energy of the ball decreases as the gravitational potential energy decreases.
- B** The kinetic energy of the ball decreases as the gravitational potential energy increases.
- C** The kinetic energy of the ball increases as the gravitational potential energy decreases.
- D** The total energy of the ball increases.

556. 9702_s20_qp_11 Q: 18

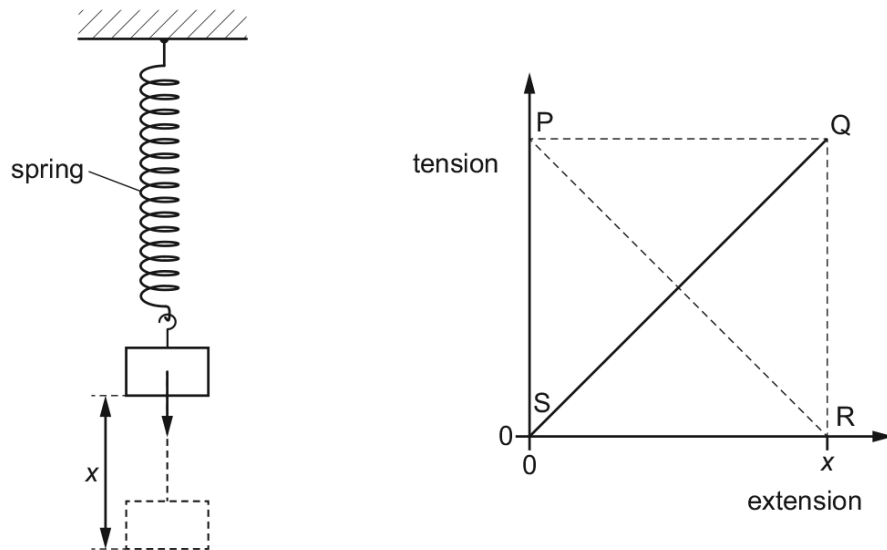
A ball is dropped from rest and falls towards the ground. Air resistance is negligible.

Which graph shows the variation with speed of the height of the ball above the ground?



557. 9702_s20_qp_12 Q: 16

A spring is attached at one end to a fixed point. A mass is then hung from the other end of the spring. The spring has extension x when the system is in equilibrium.



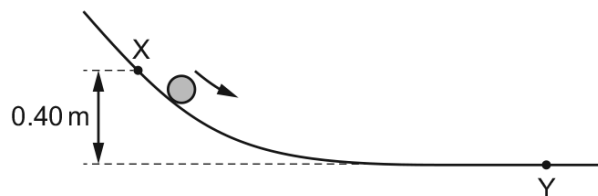
The variation of the tension in the spring with its extension is shown on the graph.

Which statement is correct?

- A** Area SPR represents the energy stored in the spring which cannot be recovered.
- B** Area SPQR represents the energy stored in the spring which can be recovered.
- C** Area SPQ represents the loss of gravitational potential energy of the mass due to the extension of the spring.
- D** Area SQR represents the elastic potential energy stored in the spring.

558. 9702_s20_qp_13 Q: 18

A ball slides down a curved track, as shown.



Point X is at a height of 0.40 m above point Y. The speed of the ball at point X is 2.5 ms^{-1} .

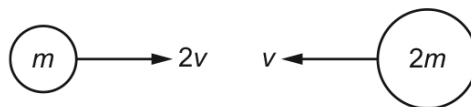
Frictional forces are negligible.

What is the speed of the ball at point Y?

- A** 2.8 ms^{-1}
- B** 3.2 ms^{-1}
- C** 3.8 ms^{-1}
- D** 14 ms^{-1}

559. 9702_m19_qp_12 Q: 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** $\frac{9}{2}mv^2$

560. 9702_s19_qp_11 Q: 18

The kinetic energy E_k of an object of mass m moving at speed v is given by the equation shown.

$$E_k = \frac{1}{2}mv^2$$

Which equation is **not** used in the derivation of this equation?

- A** $F = ma$ **B** $s = vt$ **C** $v^2 = u^2 + 2as$ **D** $W = Fs$

561. 9702_s19_qp_12 Q: 16

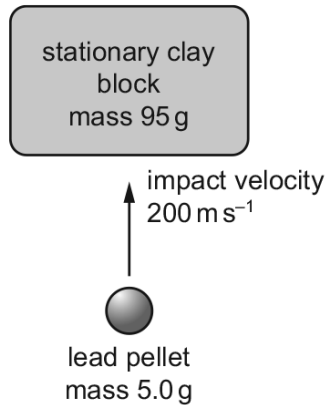
A parachutist is falling at constant (terminal) velocity.

Which statement is **not** correct?

- A** Gravitational potential energy is converted into kinetic energy of the air.
B Gravitational potential energy is converted into kinetic energy of the parachutist.
C Gravitational potential energy is converted into thermal energy of the air.
D Gravitational potential energy is converted into thermal energy of the parachutist.

562. 9702_s19_qp_13 Q: 17

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.



The mass of the pellet is 5.0 g and the mass of the clay block is 95 g.

The pellet hits the block with an initial vertical 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?

- A** 5.1 m **B** 5.6 m **C** 10 m **D** 100 m

563. 9702_s19_qp_13 Q: 18

On the surface of a planet, 30 J of work is done against gravity to raise a mass of 1.0 kg through a height of 10 m.

How much work must be done to raise a mass of 4.0 kg through a height of 5.0 m on this planet?

- A** 15 J **B** 60 J **C** 120 J **D** 200 J

564. 9702_w19_qp_11 Q: 17

An object travelling with a speed of 10 m s^{-1} has kinetic energy 1500 J.

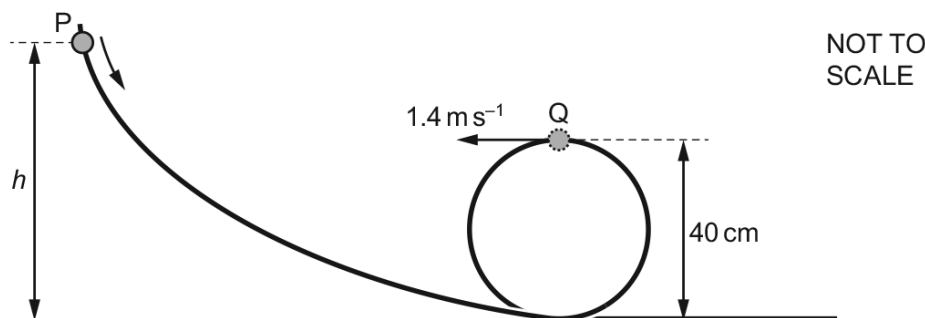
The speed of the object is increased to 40 m s^{-1} .

What is the new kinetic energy of the object?

- A** 4500 J **B** 6000 J **C** 24000 J **D** 1350000 J

565. 9702_m18_qp_12 Q: 16

A bead is released from rest at point P and slides along a wire, as shown.



The track loops around and forms a vertical circle of diameter 40 cm. At point Q, the bead has a speed of 1.4 m s^{-1} .

Air resistance and friction on the wire are negligible.

What is the height h from which the bead is released?

- A** 0.30 m **B** 0.40 m **C** 0.50 m **D** 0.60 m

566. 9702_s18_qp_11 Q: 15

A cannon-ball of mass 3.50 kg is fired at a speed of 22.0 m s^{-1} from a gun on a ship at a height of 6.00 m above sea level.

The total energy of the cannon-ball is the sum of the gravitational potential energy relative to the surface of the sea and the kinetic energy.

What is the total energy of the cannon-ball as it leaves the gun?

- A** 206 J **B** 641 J **C** 847 J **D** 1050 J

567. 9702_s18_qp_12 Q: 18

A steel sphere is dropped vertically onto a horizontal metal plate. The sphere hits the plate with speed u , leaves it at speed v , and rebounds vertically to half of its original height. Ignore air resistance.

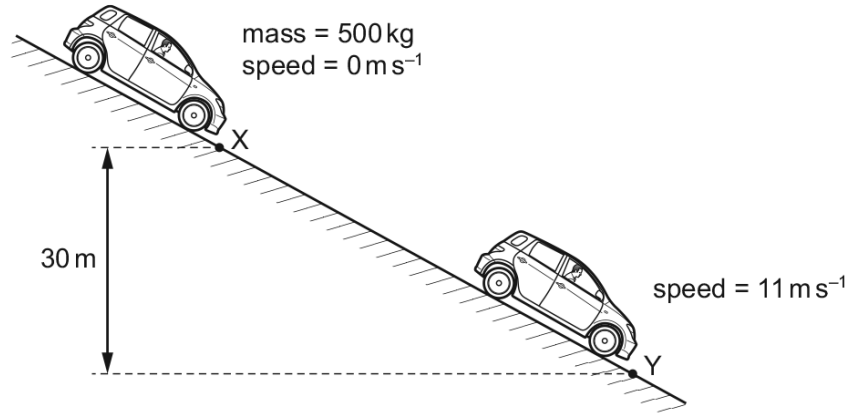
Which expression gives the value of $\frac{v}{u}$?

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

568. 9702_s18_qp_12 Q: 19

A car of mass 500 kg is at rest at point X on a slope, as shown.

The car's brakes are released and the car rolls down the slope with its engine switched off. At point Y the car has moved through a vertical height of 30 m and has a speed of 11 m s^{-1} .

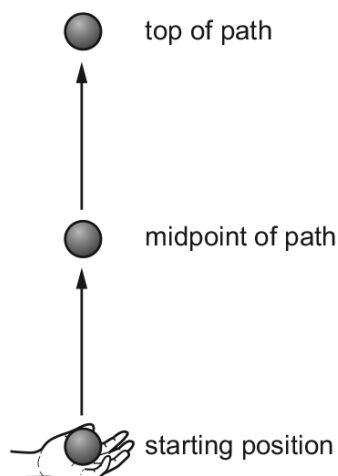


What is the energy dissipated by frictional forces when the car moves from X to Y?

- A** $3.0 \times 10^4 \text{ J}$ **B** $1.2 \times 10^5 \text{ J}$ **C** $1.5 \times 10^5 \text{ J}$ **D** $1.8 \times 10^5 \text{ J}$

569. 9702_s18_qp_13 Q: 16

A ball is thrown vertically up into the air. It rises to the top of its path before beginning to fall vertically downwards.



Assume that the gravitational potential energy of the ball is zero at its starting position.

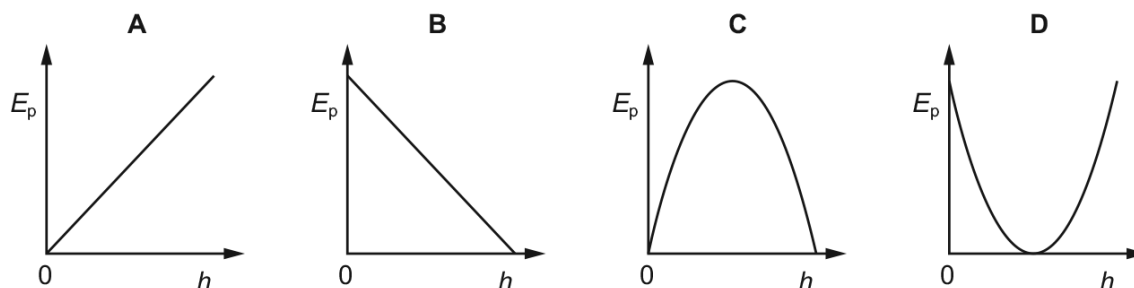
Which statement about the ball is **not** correct?

- A** As it rises, its kinetic energy is transferred to gravitational potential energy.
- B** At the midpoint of its path, its gravitational potential energy is equal to its initial kinetic energy.
- C** At the top of its path, its kinetic energy is zero.
- D** At the top of its path, its total energy is less than its initial total energy.

570. 9702_w18_qp_12 Q: 17

An object is thrown into the air.

Which graph shows how the gravitational potential energy E_p of the object varies with height h above the ground?



571. 9702_s17_qp_12 Q: 15

A cyclist is travelling at a constant speed up a hill. The frictional force resisting the cyclist's motion is 8.0 N.

The cyclist uses 450 J of energy to travel a distance of 20 m.

What is the increase in the gravitational potential energy of the cyclist?

- A** 160 J **B** 290 J **C** 440 J **D** 610 J
-

572. 9702_s17_qp_12 Q: 16

A stone of mass m falls from rest at the top of a cliff of height h into the sea below. Just before hitting the sea the stone has speed v .

What is the average force of air resistance acting on the stone during its fall?

- A** mg **B** $\frac{m(v^2 - 2gh)}{h}$ **C** $m\left(g - \frac{v^2}{2h}\right)$ **D** $m\left(gh - \frac{v^2}{2}\right)$
-

573. 9702_w17_qp_11 Q: 15

The derivation of the pressure equation $\Delta p = \rho g \Delta h$ uses a number of relationships between quantities.

Which relationship is **not** used in the derivation of this equation?

- A** density = $\frac{\text{mass}}{\text{volume}}$
B potential energy = mass $\times$ acceleration of free fall $\times$ height
C pressure = $\frac{\text{force}}{\text{area}}$
D weight = mass $\times$ acceleration of free fall
-

574. 9702_w17_qp_11 Q: 18

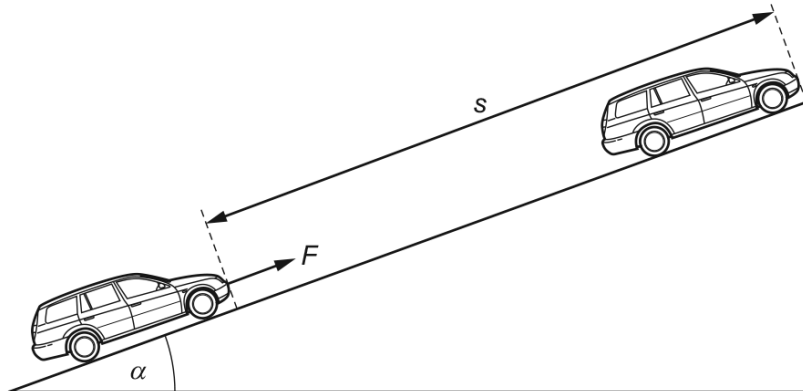
A stone is projected vertically upwards from the ground at an initial speed of 15 ms^{-1} . Air resistance is negligible.

What is the maximum height reached by the stone?

- A** 0.76 m **B** 11 m **C** 23 m **D** 110 m
-

575. 9702_w17_qp_12 Q: 17

A constant force F , acting on a car of mass m , moves the car up a slope through a distance s at constant velocity v . The angle of the slope to the horizontal is α .



What is the ratio $\frac{\text{gravitational potential energy gained by car}}{\text{work done by force } F}$?

- A $\frac{mgs \sin \alpha}{Fv}$ B $\frac{mv}{Fs}$ C $\frac{mv^2}{2Fs}$ D $\frac{mg \sin \alpha}{F}$

576. 9702_w17_qp_12 Q: 18

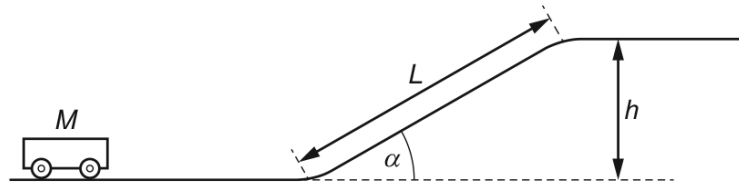
Car X is travelling at half the speed of car Y. Car X has twice the mass of car Y.

Which statement is correct?

- A Car X has half the kinetic energy of car Y.
B Car X has one quarter of the kinetic energy of car Y.
C Car X has twice the kinetic energy of car Y.
D The two cars have the same kinetic energy.

577. 9702_w17_qp_13 Q: 18

A trolley rolls along a horizontal surface and then travels up a slope before reaching a second horizontal surface. The slope is of length L . The trolley has mass M . The slope is at an angle α to the horizontal surface. The second horizontal surface is at height h above the first surface.



Assume negligible frictional forces. The acceleration of free fall is known.

In order to determine the minimum initial velocity of the trolley for it to reach the top of the slope, which additional values are needed?

- A** h and M **B** M , L and h **C** α , L , M **D** h only

578. 9702_m16_qp_12 Q: 16

A man is running in a straight line.

What is an approximate value of his kinetic energy?

- A** 10 J **B** 100 J **C** 1000 J **D** 10 000 J

579. 9702_s16_qp_11 Q: 19

A hammer with 10 J of kinetic energy hits a nail and pushes it 5.0 mm into a plank.

Both the hammer and nail come to rest after the collision.

What is the approximate average force that acts on the nail while it moves through 5.0 mm?

- A** 0.050 N **B** 2.0 N **C** 50 N **D** 2000 N

580. 9702_s16_qp_12 Q: 17

A boy on a bicycle starts from rest and rolls down a hill inclined at 30° to the horizontal.

The boy and bicycle have a combined mass of 25 kg.

There is a frictional force of 30 N, which is independent of the velocity of the bicycle.

What is the kinetic energy of the boy and the bicycle after rolling 20 m down the slope?

- A** 1850 J **B** 2450 J **C** 3050 J **D** 3640 J

581. 9702_s16_qp_13 Q: 17

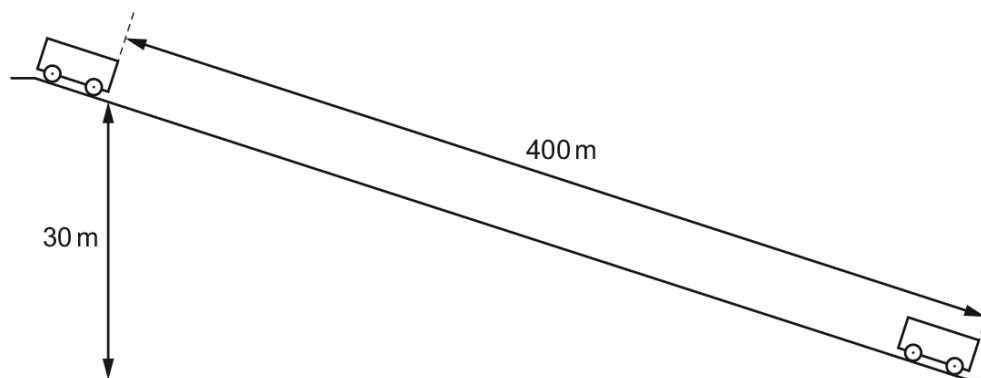
An object of mass 0.30 kg is thrown vertically upwards from the ground with an initial velocity of 8.0 ms^{-1} . The object reaches a maximum height of 1.9 m.

How much work is done against air resistance as the object rises to its maximum height?

- A** 4.0 J **B** 5.6 J **C** 9.6 J **D** 15 J

582. 9702_w16_qp_11 Q: 19

A truck of mass 500 kg moves from rest at the top of a section of track 400 m long and 30 m high, as shown. The frictional force acting on the truck is 250 N throughout its journey.



What is the final speed of the truck?

- A** 14 ms^{-1} **B** 24 ms^{-1} **C** 31 ms^{-1} **D** 190 ms^{-1}

583. 9702_w16_qp_12 Q: 18

On the surface of a planet, 30 J of work is done against gravity to raise a mass of 1.0 kg through a height of 10 m.

How much work must be done to raise a mass of 4.0 kg through a height of 5.0 m on this planet?

- A** 15 J **B** 60 J **C** 120 J **D** 200 J

584. 9702_w16_qp_12 Q: 19

The speed of a car increases from 10 m s^{-1} to 15 m s^{-1} and its kinetic energy increases by E_1 .

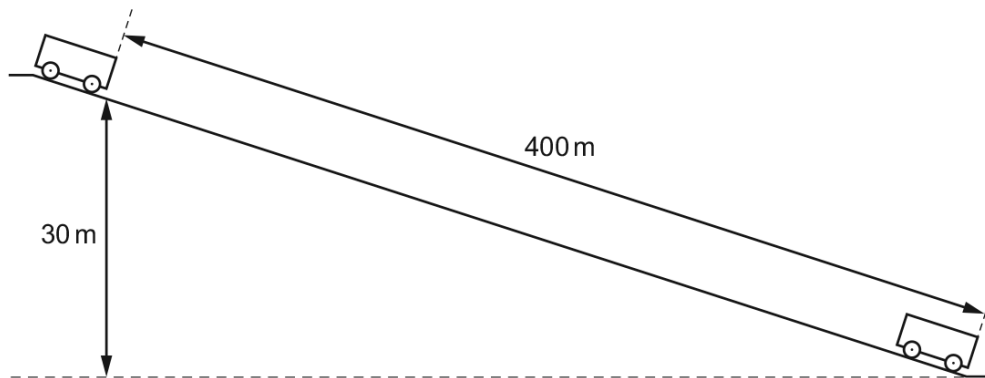
Later, the speed of the car increases from 15 m s^{-1} to 25 m s^{-1} and its kinetic energy increases by E_2 .

What is the ratio $\frac{E_2}{E_1}$?

A 1.6**B** 2.6**C** 3.2**D** 4.0

585. 9702_w16_qp_13 Q: 19

A truck of mass 500 kg moves from rest at the top of a section of track 400 m long and 30 m high, as shown. The frictional force acting on the truck is 250 N throughout its journey.

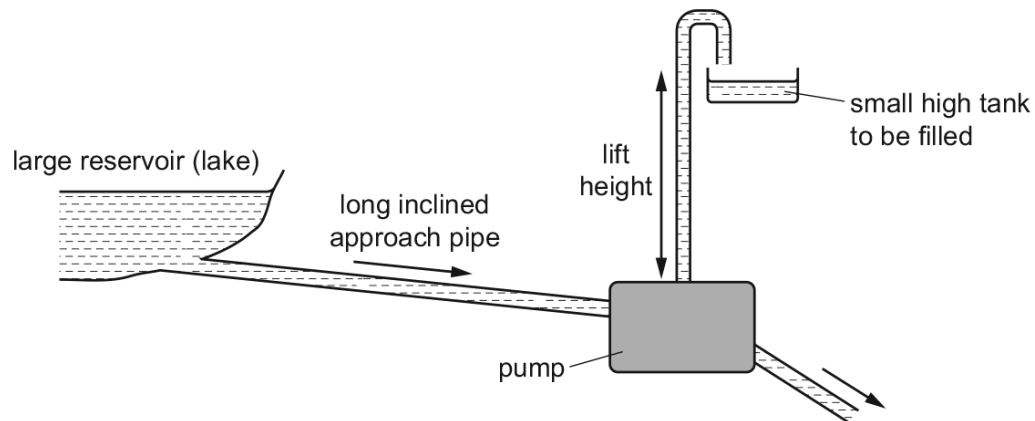


What is the final speed of the truck?

A 14 m s^{-1} **B** 24 m s^{-1} **C** 31 m s^{-1} **D** 190 m s^{-1}

586. 9702_s15_qp_11 Q: 18

The diagram shows a pump called a hydraulic ram.



In one such pump the long approach pipe holds 500 kg of water. A valve shuts when the speed of this water reaches 2.0 m s^{-1} and the kinetic energy of this water is used to lift a small quantity of water by a height of 15 m.

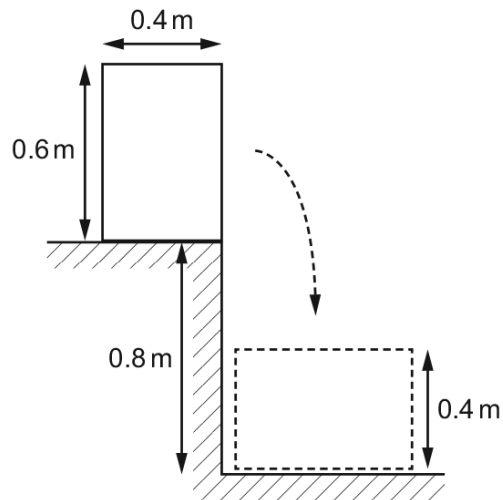
The efficiency of the pump is 10%.

Which mass of water could be lifted 15 m?

- A** 0.15 kg **B** 0.68 kg **C** 1.5 kg **D** 6.8 kg
-

587. 9702_s15_qp_12 Q: 15

A uniform solid block has weight 500 N, width 0.4 m and height 0.6 m. The block rests on the edge of a step of depth 0.8 m, as shown.



The block is knocked over the edge of the step and rotates through 90° before coming to rest with the 0.6 m edge horizontal.

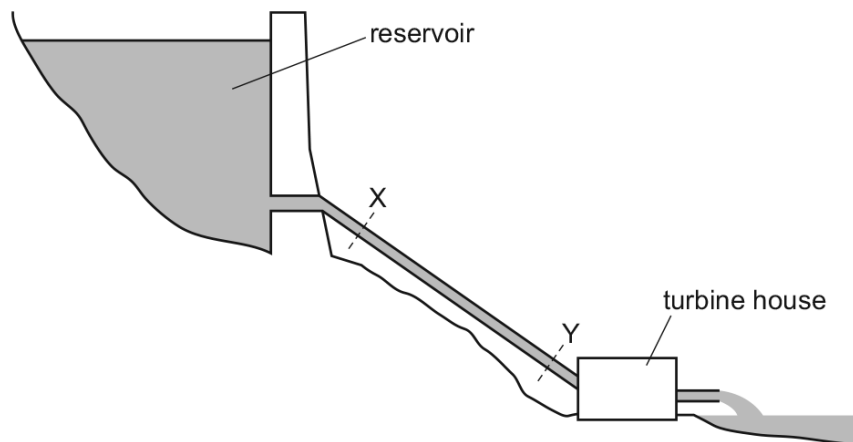
What is the change in gravitational potential energy of the block?

- A** 300 J **B** 400 J **C** 450 J **D** 550 J
-

588. 9702_s15_qp_12 Q: 16

The diagram shows a hydroelectric power station.

The reservoir is linked to the turbines by a pipe of uniform cross-sectional area.



Water flows from X to Y at constant speed. Which statement about the change of energy of the water as it moves from X to Y is correct?

- A** It gains both gravitational potential energy and kinetic energy.
- B** It loses both elastic potential energy and kinetic energy.
- C** It loses both elastic potential energy and gravitational potential energy.
- D** It loses gravitational potential energy and gains elastic potential energy.

589. 9702_s15_qp_12 Q: 17

A fisherman lifts a fish of mass 250 g from rest through a vertical height of 1.8 m. The fish gains a speed of 1.1 m s^{-1} .

What is the energy gained by the fish?

- A** 0.15 J **B** 4.3 J **C** 4.4 J **D** 4.6 J

590. 9702_s15_qp_13 Q: 18

A loaded aeroplane has a total mass of $1.2 \times 10^5 \text{ kg}$ while climbing after take-off. It climbs at an angle of 23° to the horizontal with a speed of 50 m s^{-1} . What is the rate at which it is gaining potential energy at this time?

- A** $2.3 \times 10^6 \text{ J s}^{-1}$
- B** $2.5 \times 10^6 \text{ J s}^{-1}$
- C** $2.3 \times 10^7 \text{ J s}^{-1}$
- D** $2.5 \times 10^7 \text{ J s}^{-1}$

591. 9702_s15_qp_13 Q: 19

When a horizontal force F is applied to a frictionless trolley over a distance s , the kinetic energy of the trolley changes from 4.0 J to 8.0 J.

If a force of $2F$ is applied to the trolley over a distance of $2s$, what will the original kinetic energy of 4.0 J become?

- A** 16 J **B** 20 J **C** 32 J **D** 64 J
-

6.4 Power

592. 9702_m20_qp_12 Q: 18

A car travels at a constant speed of 25 m s^{-1} up a slope. The wheels driven by the engine exert a forward force of 3000 N. The total force due to air resistance and friction is 2100 N. The weight of the car has a component down the slope of 900 N.

What is the rate at which thermal energy is dissipated?

- A** zero **B** $2.3 \times 10^4 \text{ W}$ **C** $5.3 \times 10^4 \text{ W}$ **D** $7.5 \times 10^4 \text{ W}$
-

593. 9702_s20_qp_12 Q: 17

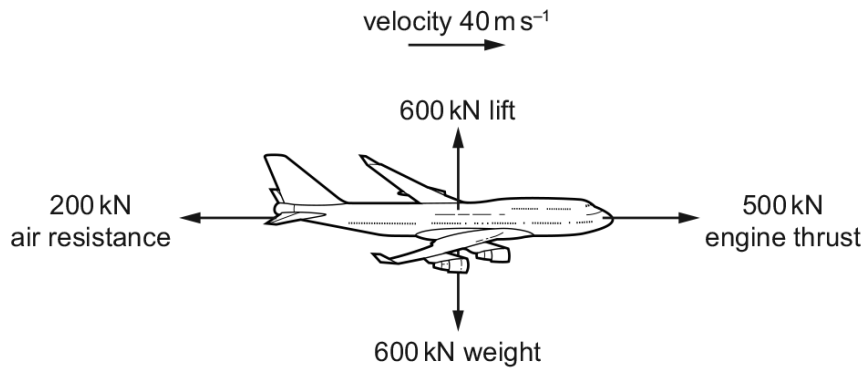
An escalator in an underground station has 25 people standing on it and is moving with a speed of 4.3 m s^{-1} . The average mass of a person is 78 kg and the angle of the escalator to the horizontal is 40° .

What is the minimum power required to lift these people?

- A** 5.4 kW **B** 6.4 kW **C** 53 kW **D** 63 kW
-

594. 9702_s20_qp_13 Q: 19

The force diagram shows an aircraft accelerating. At the instant shown, the velocity of the aircraft is 40 m s^{-1} .



At which rate is its kinetic energy increasing?

- A** 2.4 MW **B** 8.0 MW **C** 12 MW **D** 20 MW

595. 9702_m19_qp_12 Q: 17

The data below are taken from a test of a petrol engine for a motor car.

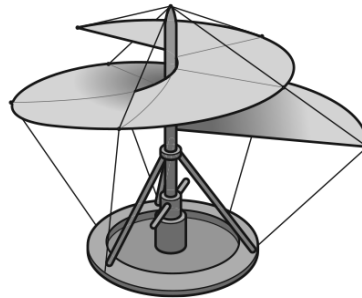
power output	150 kW
fuel consumption	20 litres per hour
energy content of fuel	40 MJ per litre

What is the ratio $\frac{\text{power output}}{\text{power input}}$?

- A** $\frac{150 \times 10^3}{40 \times 10^6 \times 20 \times 60 \times 60}$
- B** $\frac{150 \times 10^3 \times 60 \times 60}{20 \times 40 \times 10^6}$
- C** $\frac{150 \times 10^3 \times 40 \times 10^6 \times 20}{60 \times 60}$
- D** $\frac{150 \times 10^3 \times 20}{40 \times 10^3 \times 60 \times 60}$

596. 9702_m19_qp_12 Q: 18

Leonardo da Vinci proposed a flying machine that would work like a screw to lift the pilot into the air. The 'screw' is rotated by the pilot.



The machine and the pilot together have a total mass of 120 kg.

Which useful output power must the pilot provide to move vertically upwards at a constant speed of 2.5 m s^{-1} ?

- A** 48 W **B** 300 W **C** 470 W **D** 2900 W

597. 9702_s19_qp_11 Q: 19

A grasshopper of mass 0.12 g jumps vertically. It uses its back legs over a time of 0.020 s to jump, leaving the ground with a velocity of 3.0 m s^{-1} .

What is the average power developed by the legs of the grasshopper?

- A** $9.0 \times 10^{-3} \text{ W}$ **B** $1.8 \times 10^{-2} \text{ W}$ **C** $2.7 \times 10^{-2} \text{ W}$ **D** 37 W

598. 9702_s19_qp_12 Q: 19

A train on a mountain railway is carrying 200 people of average mass 70 kg up a slope at an angle of 30° to the horizontal and at a speed of 6.0 m s^{-1} . The train itself has a mass of 80 000 kg. The percentage of the power from the engine which is used to raise the passengers and the train is 40%.

What is the power of the engine?

- A** 1.1 MW **B** 2.8 MW **C** 6.9 MW **D** 14 MW

599. 9702_s19_qp_13 Q: 16

A student can run or walk up the stairs to her classroom.

Which statement describes the power required and the gravitational potential energy gained while running up the stairs compared to walking up them?

- A** Running provides more gravitational potential energy and uses more power.
- B** Running provides more gravitational potential energy and uses the same power.
- C** Running provides the same gravitational potential energy and uses more power.
- D** Running provides the same gravitational potential energy and uses the same power.

600. 9702_w19_qp_11 Q: 18

The engine of a car exerts a force of 600 N in moving the car 1.0 km in 150 seconds.

What is the average useful output power of the engine?

- A** 4.0 W **B** 4.0 kW **C** 90 kW **D** 90 MW

601. 9702_w19_qp_12 Q: 15

A power station using coal as fuel has an average power output of 3000 MW. Coal is supplied by 20 trains each day. The efficiency of the station in converting the thermal energy released from the coal to electrical energy is 26%.

A mass of 1.0 kg of coal will release 33 MJ of thermal energy when burnt.

Which mass of coal does each train bring?

- A** 2.5×10^4 kg **B** 6.3×10^4 kg **C** 1.5×10^6 kg **D** 3.0×10^7 kg

602. 9702_w19_qp_12 Q: 17

The motor of a crane lifts a load of mass 600 kg. The load rises vertically at a constant speed of 12 m per minute.

What is the useful power output of the motor?

- A** 0.12 kW **B** 1.2 kW **C** 7.2 kW **D** 71 kW
-

603. 9702_w19_qp_13 Q: 14

Trains supply coal to a power station. The table shows quantities describing the operation of the power station.

	symbol	unit
power station average output	P	W
number of trains per day	N	
mass of coal on a train	M	kg
energy from 1 kg of coal	E	J
number of seconds in one day	S	

Which expression gives the efficiency of the power station?

A $\frac{PS}{NME}$

B $\frac{PSN}{ME}$

C $\frac{NME}{PS}$

D $\frac{NM}{PSE}$

604. 9702_w19_qp_13 Q: 17

The maximum useful output power of a car travelling on a horizontal road is P . The total resistive force acting on the car is kv^2 , where v is the speed of the car and k is a constant.

Which equation is correct when the car is travelling at maximum speed?

A $v^3 = \frac{P}{k}$

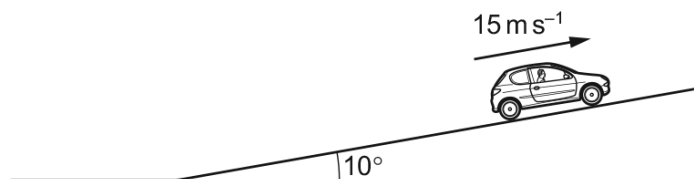
B $v^2 = \frac{P}{k}$

C $v = \left(\frac{P}{k}\right)^2$

D $v = \left(\frac{P}{k}\right)^3$

605. 9702_m18_qp_12 Q: 14

A car of mass 1100 kg is travelling at a constant speed of 15 m s^{-1} up a slope inclined at 10° to the horizontal. The combined frictional forces acting on the car are directed down the slope and are equal to $\frac{W}{5}$, where W is the weight of the car.



What is the useful output power of the car's engine?

A 28 kW

B 32 kW

C 60 kW

D 190 kW

606. 9702_m18_qp_12 Q: 17

A small diesel engine uses a volume of $1.5 \times 10^4 \text{ cm}^3$ of fuel per hour to produce a useful power output of 40 kW. It may be assumed that 34 kJ of energy is transferred to the engine when it uses 1.0 cm^3 of fuel.

What is the rate of transfer from the engine of energy that is wasted?

- A** 102 kW **B** 142 kW **C** 182 kW **D** 470 kW

607. 9702_s18_qp_11 Q: 14

A train of mass $3.3 \times 10^6 \text{ kg}$ is moving at a constant speed up a slope inclined at an angle of 0.64° to the horizontal. The engine of the train is producing a useful output power of 14 MW.

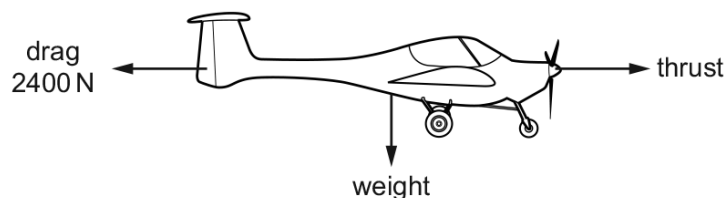
Assume that there are no frictional forces opposing the motion of the train.

What is the speed of the train?

- A** 0.43 ms^{-1} **B** 4.2 ms^{-1} **C** 39 ms^{-1} **D** 380 ms^{-1}

608. 9702_s18_qp_11 Q: 16

An aircraft travels at a constant velocity of 90 ms^{-1} in horizontal flight. The diagram shows some of the forces acting on the aircraft.



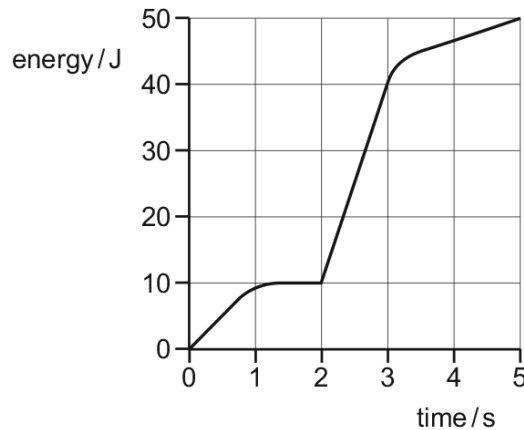
The mass of the aircraft is 2000 kg.

What is the power produced by the thrust force?

- A** $1.8 \times 10^5 \text{ W}$ **B** $2.2 \times 10^5 \text{ W}$ **C** $1.8 \times 10^6 \text{ W}$ **D** $2.0 \times 10^6 \text{ W}$

609. 9702_s18_qp_11 Q: 17

An electrical generator is started at time zero. The total electrical energy generated during the first 5 seconds is shown in the graph.



What is the maximum electrical power generated at any instant during these first 5 seconds?

- A** 10 W **B** 13 W **C** 30 W **D** 50 W

610. 9702_s18_qp_12 Q: 16

In 'normal driving conditions', an electric car has a range of 150 km. This uses all of the 200 MJ of energy stored in its batteries.

With the batteries initially fully charged, the car is driven 100 km in 'normal driving conditions'. The batteries are then recharged from a household electrical supply delivering a constant current of 13.0 A at a potential difference of 230 V.

What is the minimum time required to recharge the batteries?

- A** 0.95 hours
B 12.4 hours
C 18.6 hours
D 27.9 hours

611. 9702_s18_qp_13 Q: 17

A force of 1000 N is needed to lift the hook of a crane at a constant velocity. The crane is then used to lift a load of mass 1000 kg at a constant velocity of 0.50 m s^{-1} .

What is the power needed to lift the hook and the load?

- A** 4.9 kW **B** 5.4 kW **C** 20 kW **D** 22 kW

612. 9702_w18_qp_11 Q: 17

The force resisting the motion of a car is proportional to the square of the car's speed. The magnitude of the force at a speed of 20.0 m s^{-1} is 800 N .

What useful output power is required from the car's engine to maintain a steady speed of 40.0 m s^{-1} ?

- A** 32 kW **B** 64 kW **C** 128 kW **D** 512 kW

613. 9702_w18_qp_12 Q: 18

A car of mass 1800 kg accelerates along a horizontal road so that its speed increases from 20 m s^{-1} to 25 m s^{-1} in a time of 5.4 s .

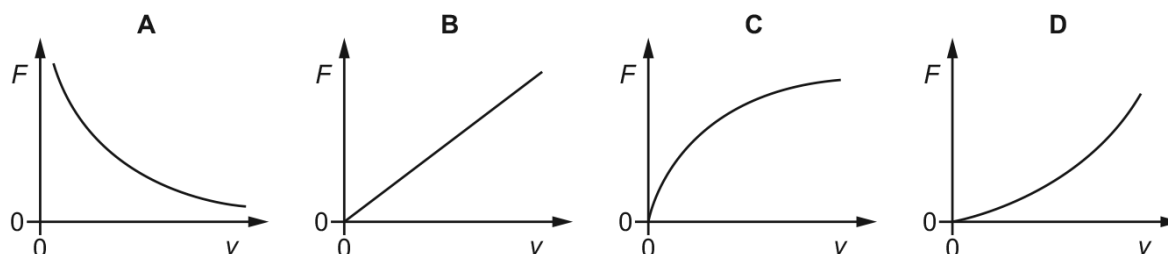
What is the average useful power output of the car's engine?

- A** 4.2 kW **B** 38 kW **C** 120 kW **D** 1100 kW

614. 9702_w18_qp_12 Q: 19

A variable force is applied to ensure that a constant power is supplied to a train.

Which graph best shows the variation of the force F applied with the velocity v of the train?



615. 9702_w18_qp_13 Q: 16

An electric kettle is rated as having an input power of 1.50 kW and an efficiency of 65.0%.

The kettle is switched on for 2.00 minutes.

How much energy is transferred to the water in the kettle?

- A** 0.975 kJ **B** 117 kJ **C** 180 kJ **D** 277 kJ

616. 9702_w18_qp_13 Q: 18

A girl of mass 50 kg runs up a flight of 20 steps in 7.0 seconds. Each step is 25 cm high.

What is the useful average output power provided by the girl to climb the flight of steps?

- A** 18 W **B** 36 W **C** 350 W **D** 2500 W

617. 9702_m17_qp_12 Q: 19

A car of mass 1400 kg is travelling on a straight, horizontal road at a constant speed of 25 m s^{-1} . The output power from the car's engine is 30 kW.

The car then travels up a slope at 2° to the horizontal, maintaining the same constant speed.



What is the output power of the car's engine when travelling up the slope?

- A** 12 kW **B** 31 kW **C** 42 kW **D** 65 kW

618. 9702_s17_qp_11 Q: 18

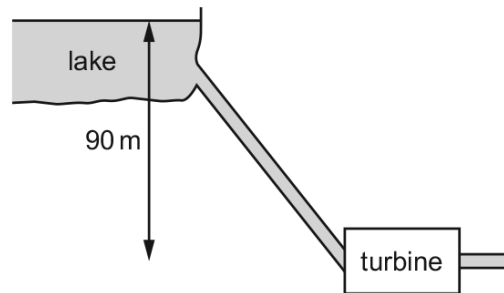
A mass is raised vertically. In time t , the increase in its gravitational potential energy is E_p and the increase in its kinetic energy is E_k .

What is the average power input to the mass?

- A** $(E_p - E_k)t$ **B** $(E_p + E_k)t$ **C** $\frac{E_p - E_k}{t}$ **D** $\frac{E_p + E_k}{t}$

619. 9702_s17_qp_11 Q: 19

Water flows from a lake into a turbine that is a vertical distance of 90 m below the lake, as shown.



The mass flow rate of the water is 2400 kg min^{-1} . The turbine has an efficiency of 75%.

What is the output power of the turbine?

- A** 26 kW **B** 35 kW **C** 1.6 MW **D** 2.1 MW

620. 9702_s17_qp_12 Q: 18

What is a correct derivation of the equation relating power, force and velocity?

- A** $\text{power} = \frac{\text{work done}}{\text{time taken}}$ and $\text{work done} = \text{force} \times \text{displacement}$

$$\text{so power} = \frac{\text{force} \times \text{displacement}}{\text{time taken}}$$

$$\text{so power} = \text{force} \times \text{velocity}$$

- B** $\text{power} = \frac{\text{work done}}{\text{time taken}}$ and $\text{work done} = \text{force} \times \text{distance}$

$$\text{so power} = \frac{\text{force} \times \text{distance}}{\text{time taken}}$$

$$\text{so power} = \text{force} \times \text{velocity}$$

- C** $\text{power} = \frac{\text{work done}}{\text{time taken}}$ and $\text{work done} = \frac{\text{force}}{\text{displacement}}$

$$\text{so power} = \frac{\text{force}}{\text{displacement}} \times \text{time taken}$$

$$\text{so power} = \frac{\text{force}}{\text{velocity}}$$

- D** $\text{power} = \frac{\text{work done}}{\text{time taken}}$ and $\text{work done} = \frac{\text{force}}{\text{distance}}$

$$\text{so power} = \frac{\text{force}}{\text{distance}} \times \text{time taken}$$

$$\text{so power} = \frac{\text{force}}{\text{velocity}}$$

621. 9702_s17_qp_13 Q: 17

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** $\sqrt{v} \propto m$
-

622. 9702_w17_qp_11 Q: 3

An ion is accelerated in a vacuum by a series of electrodes. A graph of the power supplied to the ion is plotted against time.

What is represented by the area under the graph between two times?

- A** the average force on the ion
B the change in kinetic energy of the ion
C the change in momentum of the ion
D the change in velocity of the ion
-

623. 9702_w17_qp_11 Q: 19

A turbine at a hydroelectric power station is situated 30 m below the level of the surface of a large lake. The water passes through the turbine at a rate of 340 m^3 per minute.

The overall efficiency of the turbine and generator system is 90%.

What is the output power of the power station? (The density of water is 1000 kg m^{-3} .)

- A** 0.15 MW **B** 1.5 MW **C** 1.7 MW **D** 90 MW
-

624. 9702_w17_qp_12 Q: 19

During refuelling, a petrol car receives 50 litres of fuel in 90 seconds. The petrol has 34 MJ of energy per litre.

For an electric car to receive the same amount of energy in the same time from a 230 V supply, what is the minimum current required?

- A** 2700 A **B** $8.2 \times 10^4 \text{ A}$ **C** $7.4 \times 10^6 \text{ A}$ **D** $6.6 \times 10^8 \text{ A}$
-

625. 9702_w17_qp_13 Q: 16

A car of total mass 1560 kg is travelling with a constant speed of 32 ms^{-1} . The driving force provided by the car is 680 N . The kinetic energy of the car is 800 kJ and its momentum is 50000 N s .

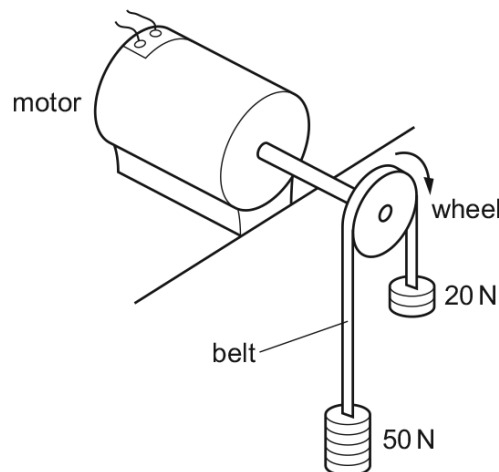
Which two items of data could be used to calculate the useful power output of the car?

- A** driving force and momentum
- B** kinetic energy and mass
- C** mass and momentum
- D** speed and driving force

626. 9702_w17_qp_13 Q: 19

The diagram shows an arrangement used to find the output power of an electric motor.

The wheel attached to the motor's axle has a circumference of 0.5 m and the belt which passes over it is stationary when the weights have the values shown.

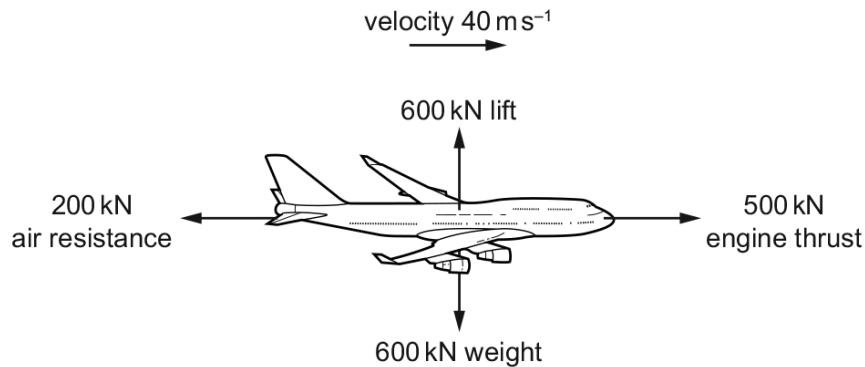


When the wheel is making 20 revolutions per second, what is the output power of the motor?

- A** 300 W
- B** 500 W
- C** 600 W
- D** 700 W

627. 9702_m16_qp_12 Q: 15

The force diagram shows an aircraft accelerating. At the instant shown, the velocity of the aircraft is 40 m s^{-1} .



At which rate is its kinetic energy increasing?

- A** 2.4 MW **B** 8.0 MW **C** 12 MW **D** 20 MW

628. 9702_s16_qp_11 Q: 17

The power P required to move an object through a medium at constant speed depends on the speed v and the resistive force F acting on the object.

The resistive force F also depends on the speed v .

Which row shows a possible relationship between speed v , resistive force F and power P ?

	resistive force F	power P
A	proportional to v	constant
B	proportional to v	proportional to v
C	proportional to v^2	proportional to v^2
D	proportional to v^2	proportional to v^3

629. 9702_s16_qp_11 Q: 18

Which amount of energy is **not** 2400 J?

- A** the decrease in gravitational potential energy of a body of mass 60 kg when it moves vertically downwards through 40 m near the Earth's surface
- B** the energy transferred in 15 s by a machine of power 160 W
- C** the kinetic energy of a body of mass 12 kg moving at a speed of 20 m s^{-1}
- D** the work done by a gas expanding against a constant external pressure of 120 kPa when its volume increases by 0.020 m^3

630. 9702_s16_qp_12 Q: 18

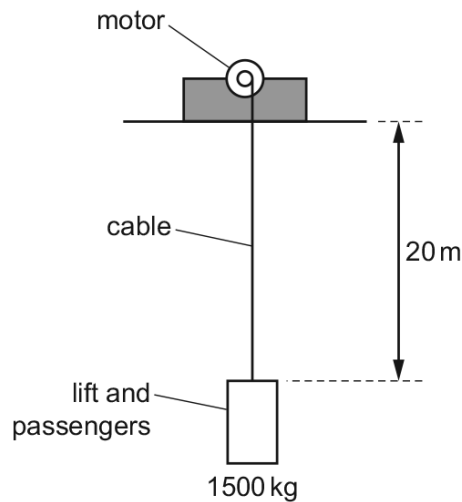
An escalator in an underground station has 250 people standing on it and is moving with a velocity of 4.3 m s^{-1} . The average mass of a person is 78 kg and the angle of the escalator to the horizontal is 40° .

What is the minimum power required to lift these people?

- A** 54 kW **B** 64 kW **C** 530 kW **D** 630 kW

631. 9702_s16_qp_12 Q: 19

An electric motor operating a lift has an output power of 20 kW.



The lift and passengers have a combined mass of 1500 kg. The motor raises the lift through a distance of 20 m.

How long does it take?

- A** 6 s **B** 15 s **C** 30 s **D** 60 s

632. 9702_s16_qp_13 Q: 18

A racing car has an output power of 300 kW when travelling at a constant speed of 60 m s^{-1} .

What is the total resistive force acting on the car?

- A** 5 kN **B** 10 kN **C** 50 kN **D** 100 kN
-

633. 9702_w16_qp_11 Q: 17

A hydroelectric power station uses the gravitational potential energy of water to generate electrical energy.

In one particular power station, the mass of water flowing per unit time is $1.5 \times 10^5 \text{ kg s}^{-1}$. The water falls through a height of 120 m.

The electrical power generated is 100 MW.

What is the efficiency of the power station?

- A** 5.6% **B** 43% **C** 57% **D** 68%
-

634. 9702_w16_qp_12 Q: 20

A car travels at a constant speed of 25 m s^{-1} up a slope. The wheels driven by the engine exert a forward force of 3000 N. There is a drag force due to air resistance and friction of 2100 N. The weight of the car has a component down the slope of 900 N.

What is the rate at which thermal energy is dissipated?

- A** zero **B** $2.3 \times 10^4 \text{ W}$ **C** $5.3 \times 10^4 \text{ W}$ **D** $7.5 \times 10^4 \text{ W}$
-

635. 9702_w16_qp_13 Q: 17

A hydroelectric power station uses the gravitational potential energy of water to generate electrical energy.

In one particular power station, the mass of water flowing per unit time is $1.5 \times 10^5 \text{ kg s}^{-1}$. The water falls through a height of 120 m.

The electrical power generated is 100 MW.

What is the efficiency of the power station?

- A** 5.6% **B** 43% **C** 57% **D** 68%
-

636. 9702_s15_qp_11 Q: 17

Which statement is correct?

- A** A ball lands on the ground and bounces. The kinetic energy changes sign, because the ball changes direction.
 - B** A car drives up a slope at a steady speed. The power generated by the engine equals the potential energy gained per unit time.
 - C** An electric heater can be 100% efficient.
 - D** It is impossible for momentum to be conserved in a collision.
-

637. 9702_s15_qp_11 Q: 19

A conveyor belt is driven at velocity v by a motor. Sand drops vertically on to the belt at a rate of $m \text{ kg s}^{-1}$.

What is the additional power needed to keep the conveyor belt moving at a steady speed when the sand starts to fall on it?

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

Paper 1 Multiple Choice Answers: Work, Energy and Power

Question	Paper	Q. No.	Answer
499	9702_s20_qp_13	16	D
500	9702_m19_qp_12	15	C
501	9702_s19_qp_13	15	D
502	9702_w19_qp_13	16	B
503	9702_w18_qp_11	14	A
504	9702_w18_qp_12	15	D
505	9702_s17_qp_11	15	A
506	9702_w17_qp_13	15	A
507	9702_s16_qp_12	16	B
508	9702_s16_qp_13	16	C
509	9702_m20_qp_12	14	B
510	9702_m20_qp_12	16	D
511	9702_m20_qp_12	17	A
512	9702_s20_qp_11	17	B
513	9702_s20_qp_11	19	D
514	9702_s20_qp_12	14	C
515	9702_s20_qp_12	15	C
516	9702_s20_qp_13	17	D
517	9702_s19_qp_11	8	A
518	9702_s19_qp_11	17	C
519	9702_s19_qp_12	17	D
520	9702_w19_qp_11	15	D
521	9702_w19_qp_11	16	C
522	9702_w19_qp_12	14	A
523	9702_w19_qp_12	16	D
524	9702_w19_qp_13	15	A
525	9702_w19_qp_13	18	B
526	9702_m18_qp_12	15	C
527	9702_m18_qp_12	18	B
528	9702_s18_qp_13	14	A
529	9702_s18_qp_13	15	D
530	9702_w18_qp_11	15	B
531	9702_w18_qp_12	16	A
532	9702_w18_qp_13	15	D
533	9702_w18_qp_13	17	C
534	9702_m17_qp_12	16	A
535	9702_m17_qp_12	17	A
536	9702_s17_qp_11	16	C
537	9702_s17_qp_11	17	C
538	9702_s17_qp_12	17	C
539	9702_s17_qp_13	14	A
540	9702_s17_qp_13	15	D
541	9702_w17_qp_11	16	D
542	9702_w17_qp_11	17	A
543	9702_w17_qp_12	16	A
544	9702_w17_qp_13	17	C

Paper 1 Multiple Choice Answers: Work, Energy and Power (continued)

Question	Paper	Q. No.	Answer
545	9702_m16_qp_12	17	D
546	9702_sl6_qp_11	16	C
547	9702_w16_qp_11	18	C
548	9702_w16_qp_11	20	C
549	9702_w16_qp_12	16	C
550	9702_w16_qp_13	18	C
551	9702_w16_qp_13	20	C
552	9702_sl5_qp_11	16	C
553	9702_sl5_qp_12	18	D
554	9702_sl5_qp_13	17	A
555	9702_m20_qp_12	15	B
556	9702_s20_qp_11	18	C
557	9702_s20_qp_12	16	D
558	9702_s20_qp_13	18	C
559	9702_m19_qp_12	10	C
560	9702_sl9_qp_11	18	B
561	9702_sl9_qp_12	16	B
562	9702_sl9_qp_13	17	A
563	9702_sl9_qp_13	18	B
564	9702_w19_qp_11	17	C
565	9702_m18_qp_12	16	C
566	9702_sl8_qp_11	15	D
567	9702_sl8_qp_12	18	C
568	9702_sl8_qp_12	19	B
569	9702_sl8_qp_13	16	B
570	9702_w18_qp_12	17	A
571	9702_sl7_qp_12	15	B
572	9702_sl7_qp_12	16	C
573	9702_w17_qp_11	15	B
574	9702_w17_qp_11	18	B
575	9702_w17_qp_12	17	D
576	9702_w17_qp_12	18	A
577	9702_w17_qp_13	18	D
578	9702_m16_qp_12	16	C
579	9702_sl6_qp_11	19	D
580	9702_sl6_qp_12	17	A
581	9702_sl6_qp_13	17	A
582	9702_w16_qp_11	19	A
583	9702_w16_qp_12	18	B
584	9702_w16_qp_12	19	C
585	9702_w16_qp_13	19	A
586	9702_sl5_qp_11	18	B
587	9702_sl5_qp_12	15	C
588	9702_sl5_qp_12	16	D
589	9702_sl5_qp_12	17	D
590	9702_sl5_qp_13	18	C

Paper 1 Multiple Choice Answers: Work, Energy and Power (continued)

Question	Paper	Q. No.	Answer
591	9702_sl5_qp_13	19	B
592	9702_m20_qp_12	18	C
593	9702_s20_qp_12	17	C
594	9702_s20_qp_13	19	C
595	9702_m19_qp_12	17	B
596	9702_m19_qp_12	18	D
597	9702_sl9_qp_11	19	C
598	9702_sl9_qp_12	19	C
599	9702_sl9_qp_13	16	C
600	9702_w19_qp_11	18	B
601	9702_w19_qp_12	15	C
602	9702_w19_qp_12	17	B
603	9702_w19_qp_13	14	A
604	9702_w19_qp_13	17	A
605	9702_m18_qp_12	14	C
606	9702_m18_qp_12	17	A
607	9702_sl8_qp_11	14	C
608	9702_sl8_qp_11	16	B
609	9702_sl8_qp_11	17	C
610	9702_sl8_qp_12	16	B
611	9702_sl8_qp_13	17	B
612	9702_w18_qp_11	17	C
613	9702_w18_qp_12	18	B
614	9702_w18_qp_12	19	A
615	9702_w18_qp_13	16	B
616	9702_w18_qp_13	18	C
617	9702_m17_qp_12	19	C
618	9702_sl7_qp_11	18	D
619	9702_sl7_qp_11	19	A
620	9702_sl7_qp_12	18	A
621	9702_sl7_qp_13	17	B
622	9702_w17_qp_11	3	B
623	9702_w17_qp_11	19	B
624	9702_w17_qp_12	19	B
625	9702_w17_qp_13	16	D
626	9702_w17_qp_13	19	A
627	9702_m16_qp_12	15	C
628	9702_sl6_qp_11	17	D
629	9702_sl6_qp_11	18	A
630	9702_sl6_qp_12	18	C
631	9702_sl6_qp_12	19	B
632	9702_sl6_qp_13	18	A
633	9702_w16_qp_11	17	C
634	9702_w16_qp_12	20	C
635	9702_w16_qp_13	17	C
636	9702_sl5_qp_11	17	C

Paper 1 Multiple Choice Answers: Work, Energy and Power (continued)

Question	Paper	Q. No.	Answer
637	9702_s15_qp_11	19	D

Chapter 6

Work, energy and power

6.1 Energy conversion and conservation

68. 9702_s20_qp_21 Q: 2

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

.....
 [1]

- (b) A delivery company suggests using a remote-controlled aircraft to drop a parcel into the garden of a customer. When the aircraft is vertically above point P on the ground, it releases the parcel with a velocity that is horizontal and of magnitude 5.4 ms^{-1} . The path of the parcel is shown in Fig. 2.1.

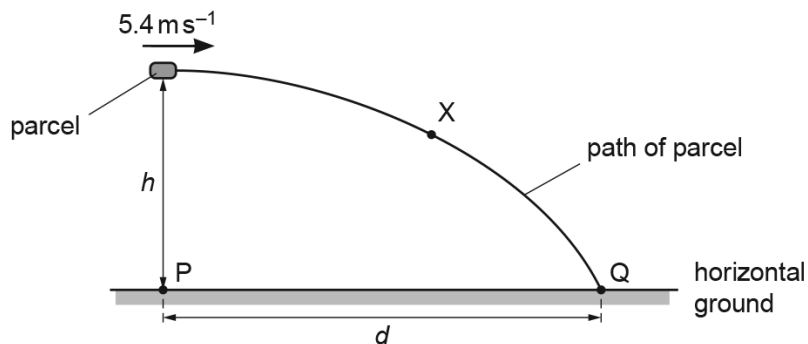


Fig. 2.1 (not to scale)

The parcel takes a time of 0.81 s after its release to reach point Q on the horizontal ground. Assume air resistance is negligible.

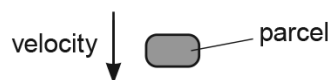
- (i) On Fig. 2.1, draw an arrow from point X to show the direction of the acceleration of the parcel when it is at that point. [1]
- (ii) Determine the height h of the parcel above the ground when it is released.

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

- (iii) Calculate the horizontal distance d between points P and Q.

$d = \dots\dots\dots \text{ m}$ [1]

- (c) Another parcel is accidentally released from rest by a different aircraft when it is hovering at a great height above the ground. Air resistance is now significant.
- (i) On Fig. 2.2, draw arrows to show the directions of the forces acting on the parcel as it falls vertically downwards. Label each arrow with the name of the force.

**Fig. 2.2**

[2]

- (ii) By considering the forces acting on the parcel, state and explain the variation, if any, of the acceleration of the parcel as it moves downwards before it reaches constant (terminal) speed.

.....

.....

.....

.....

.....

..... [3]

- (iii) Describe the energy conversion that occurs when the parcel is falling through the air at constant (terminal) speed.

.....

..... [1]

[Total: 11]

69. 9702_s17_qp_22 Q: 4

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

.....
[1]

- (b) An object A of mass 100 g is moving in a straight line with a velocity of 0.60 m s^{-1} to the right. An object B of mass 200 g is moving in the same straight line as object A with a velocity of 0.80 m s^{-1} to the left, as shown in Fig. 4.1.



Fig. 4.1

Objects A and B collide. Object A then moves with a velocity of 0.40 m s^{-1} to the left.

- (i) Calculate the magnitude of the velocity of B after the collision.

magnitude of velocity = ... m s^{-1} [2]

- (ii) The collision between A and B is inelastic.

Explain how the collision is inelastic and still obeys the law of conservation of energy.

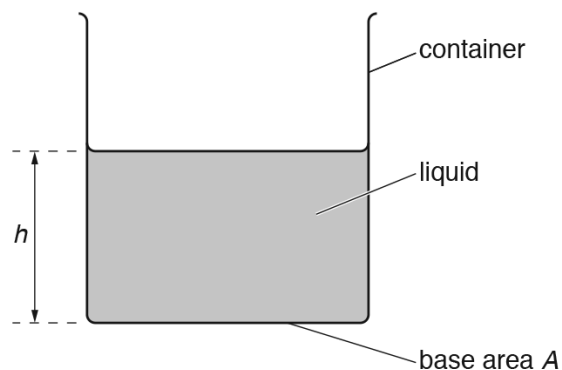
.....

[1]

[Total: 4]

70. 9702_w17_qp_23 Q: 2

A liquid of density ρ fills a container to a depth h , as shown in Fig. 2.1.

**Fig. 2.1**

The base of the container has area A .

(a) Derive, from the definitions of pressure and density, the equation

$$p = \rho gh$$

where p is the pressure exerted by the liquid on the base of the container and g is the acceleration of free fall.

[3]

(b) A small solid sphere falls with constant velocity through the liquid.

(i) State

1. the names of the three forces acting on the sphere,

.....

2. a word equation that relates the magnitudes of these forces.

.....

[2]

- (ii) State and explain the changes in energy that occur as the sphere falls.

.....

.....

.....

.....[2]

- (c) The liquid in the container is liquid L. Liquid M is now added to the container. The two liquids do not mix. The total depth of the liquids is 0.17 m.

Fig. 2.2 shows how the pressure p inside the liquids varies with height x above the base of the container.

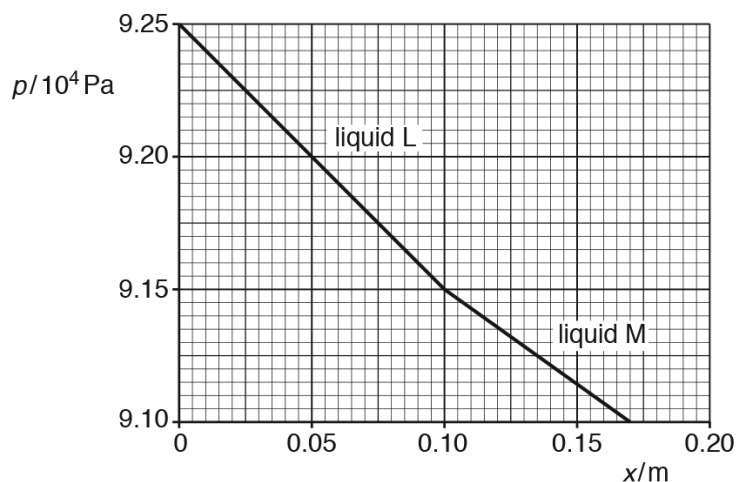


Fig. 2.2

Use Fig. 2.2 to

- (i) state the value of atmospheric pressure,

atmospheric pressure = ... Pa [1]

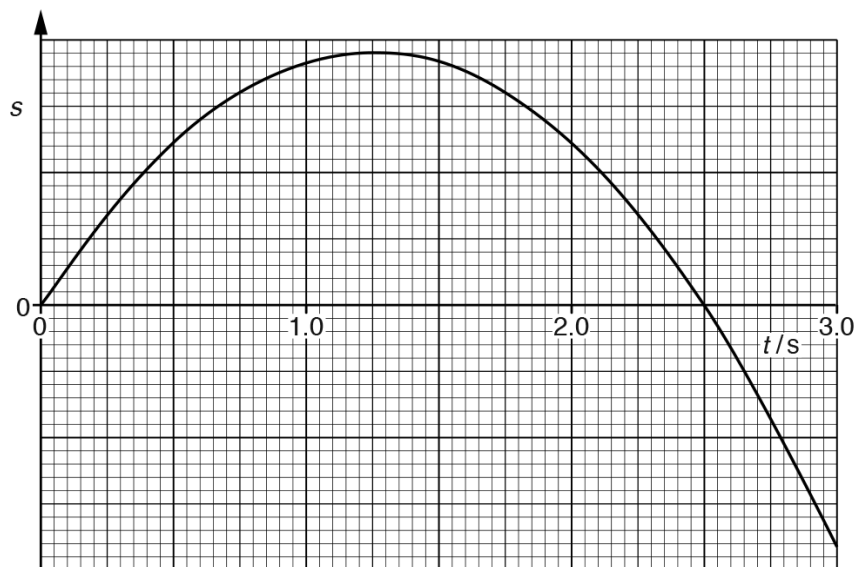
- (ii) determine the density of liquid M.

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

[Total: 10]

71. 9702_s15_qp_22 Q: 2

A stone is thrown vertically upwards. The variation with time t of the displacement s of the stone is shown in Fig. 2.1.

**Fig. 2.1**

- (a) Use Fig. 2.1 to describe, without calculation, the speed of the stone from $t = 0$ to $t = 3.0$ s.

.....

 [2]

- (b) Assume air resistance is negligible and therefore the stone has constant acceleration.

Calculate, for the stone,

- (i) the speed at 3.0 s,

speed = ... ms^{-1} [3]

- (ii) the distance travelled from $t = 0$ to $t = 3.0$ s,

distance = ... m [3]

- (iii) the displacement from $t = 0$ to $t = 3.0$ s.

displacement = ... m

direction [2]

- (c) On Fig. 2.2, draw the variation with time t of the velocity v of the stone from $t = 0$ to $t = 3.0$ s.

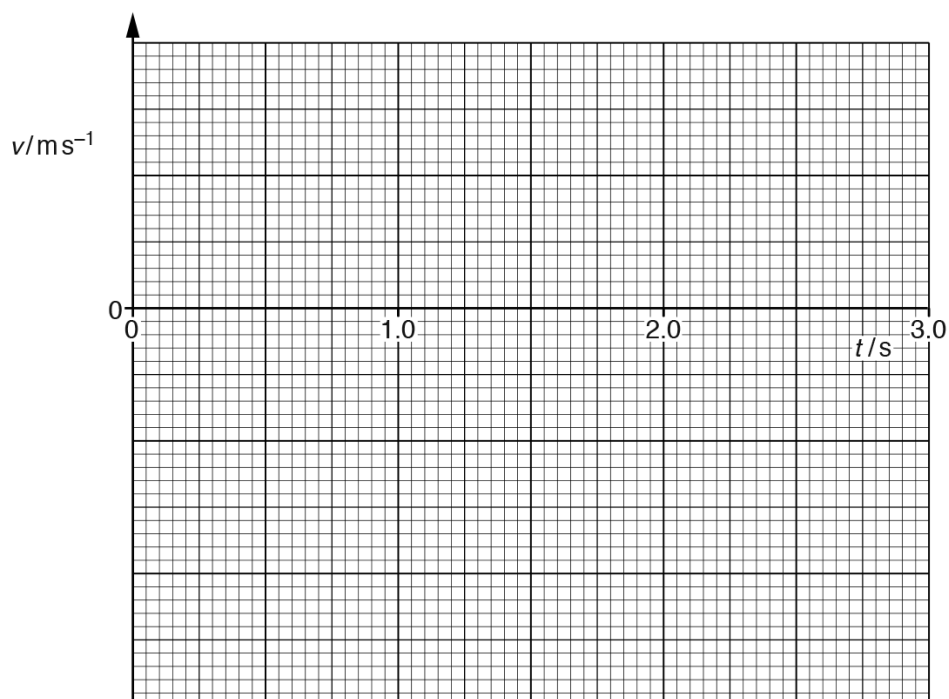


Fig. 2.2

[3]

6.2 Work and efficiency

72. 9702_w15_qp_23 Q: 4

A block is pulled on a horizontal surface by a force P as shown in Fig. 4.1.

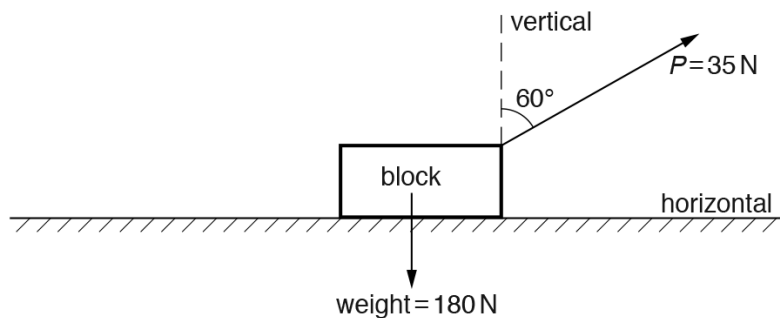


Fig. 4.1

The weight of the block is 180 N. The force P is 35 N at 60° to the vertical. The block moves a distance of 20 m at constant velocity.

(a) Calculate

(i) the vertical force that the surface applies to the block (normal reaction force),

force = ... N [2]

(ii) the work done by force P .

work done = ... J [2]

- (b) (i) Explain why the block continues to move at constant velocity although work is done on the block by force P .

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

- (ii) Explain, in terms of the forces acting, why the block remains in equilibrium.

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

6.3 Potential energy and kinetic energy

73. 9702_s20_qp_21 Q: 3

(a) State **two** conditions for an object to be in equilibrium.

1.
 -
 2.
 -
- [2]

(b) A sphere of weight 2.4N is suspended by a wire from a fixed point P. A horizontal string is used to hold the sphere in equilibrium with the wire at an angle of 53° to the horizontal, as shown in Fig. 3.1.

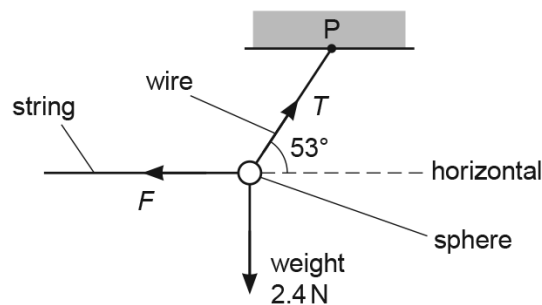


Fig. 3.1 (not to scale)

(i) Calculate:

1. the tension T in the wire

$$T = \dots\dots\dots \text{ N}$$

2. the force F exerted by the string on the sphere.

$$F = \dots\dots\dots \text{ N}$$

[2]

(ii) The wire has a circular cross-section of diameter 0.50 mm. Determine the stress σ in the wire.

$$\sigma = \dots\dots\dots \text{ Pa} \quad [3]$$

- (c) The string is disconnected from the sphere in (b). The sphere then swings from its initial rest position A, as illustrated in Fig. 3.2.

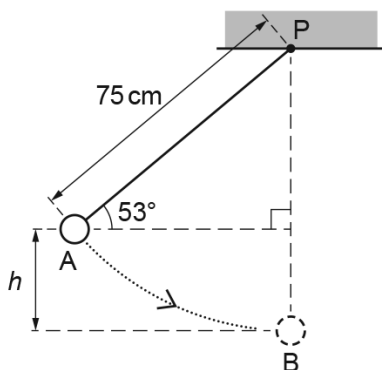


Fig. 3.2 (not to scale)

The sphere reaches maximum speed when it is at the bottom of the swing at position B. The distance between P and the centre of the sphere is 75 cm. Air resistance is negligible and energy losses at P are negligible.

- (i) Show that the vertical distance h between A and B is 15 cm.

[1]

- (ii) Calculate the change in gravitational potential energy of the sphere as it moves from A to B.

change in gravitational potential energy = ... J [2]

- (iii) Use your answer in (c)(ii) to determine the speed of the sphere at B. Show your working.

speed = ... ms^{-1} [3]

[Total: 13]

74. 9702_s20_qp_22 Q: 3

- (a) Explain what is meant by *work done*.

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

- (b) A ball of mass 0.42 kg is dropped from the top of a building. The ball falls from rest through a vertical distance of 78 m to the ground. Air resistance is significant so that the ball reaches constant (terminal) velocity before hitting the ground. The ball hits the ground with a speed of 23 m s^{-1} .

- (i) Calculate, for the ball falling from the top of the building to the ground:

1. the decrease in gravitational potential energy

decrease in gravitational potential energy = ... J [2]

2. the increase in kinetic energy.

increase in kinetic energy = ... J [2]

- (ii) Use your answers in (b)(i) to determine the average resistive force acting on the ball as it falls from the top of the building to the ground.

average resistive force = ... N [2]

- (c) The ball in (b) is dropped at time $t = 0$ and hits the ground at time $t = T$. The acceleration of free fall is g .

On Fig. 3.1, sketch a line to show the variation of the acceleration a of the ball with time t from time $t = 0$ to $t = T$.

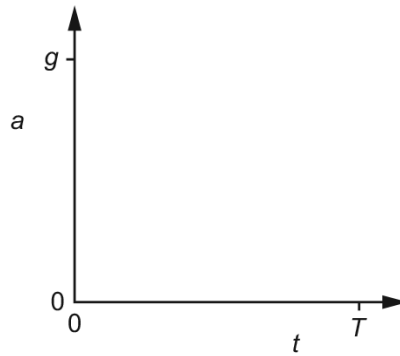


Fig. 3.1

[2]

[Total: 9]

75. 9702_w20_qp_21 Q: 2

A small block is lifted vertically upwards by a toy aircraft, as illustrated in Fig. 2.1.

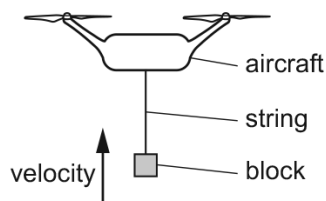


Fig. 2.1

As the block is moving upwards, the string breaks at time $t = 0$. The block initially continues moving upwards and then falls and hits the ground at time $t = 0.90$ s. The variation with time t of the velocity v of the block is shown in Fig. 2.2.

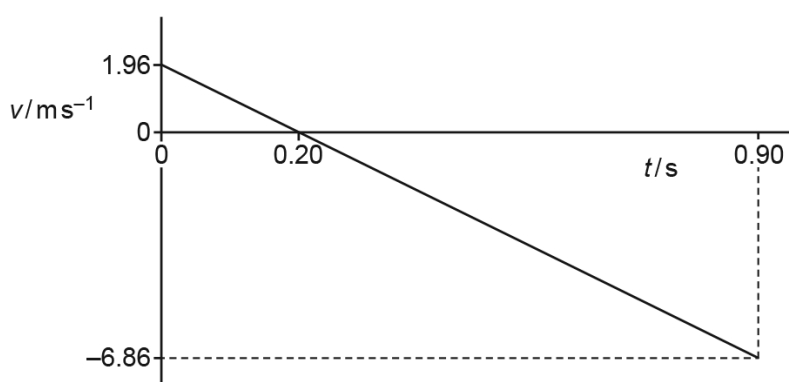


Fig. 2.2

Air resistance is negligible.

(a) State the feature of the graph in Fig. 2.2 that shows the block has a constant acceleration.

..... [1]

(b) Use Fig. 2.2 to determine the height of the block above the ground when the string breaks at time $t = 0$.

height = ... m [3]

- (c) The block has a weight of 0.86 N.

Calculate the difference in gravitational potential energy of the block between time $t = 0$ and time $t = 0.90$ s.

difference in gravitational potential energy = ... J [2]

- (d) On Fig. 2.3, sketch a line to show the variation of the distance moved by the block with time t from $t = 0$ to $t = 0.20$ s. Numerical values of distance are not required.

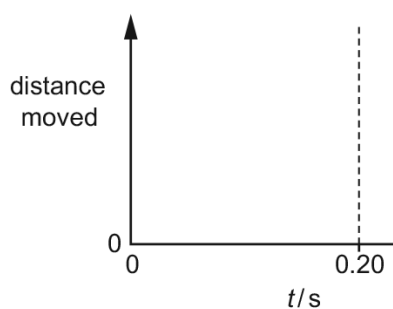


Fig. 2.3

[2]

- (e) A block of greater mass is now released from the same height with the same upward velocity. Air resistance is still negligible.

State and explain the effect, if any, of the increased mass on the speed with which the block hits the ground.

.....
 [1]

[Total: 9]

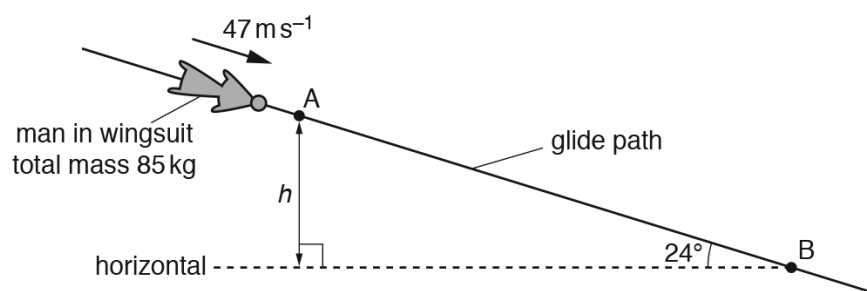
76. 9702_m19_qp_22 Q: 2

(a) Define:**(i)** *displacement*

.....
[1]

(ii) *acceleration.*

.....
[1]

(b) A man wearing a wingsuit glides through the air with a constant velocity of 47 ms^{-1} at an angle of 24° to the horizontal. The path of the man is shown in Fig. 2.1.**Fig. 2.1** (not to scale)

The total mass of the man and the wingsuit is 85 kg. The man takes a time of 2.8 minutes to glide from point A to point B.

(i) With reference to the motion of the man, state and explain whether he is in equilibrium.

.....

[2]

(ii) Show that the difference in height h between points A and B is 3200 m.

[1]

(iii) For the movement of the man from A to B, determine:

1. the decrease in gravitational potential energy

decrease in gravitational potential energy = ... J [2]

2. the magnitude of the force on the man due to air resistance.

force = ... N [2]

(iv) The pressure of the still air at A is 63 kPa and at B is 92 kPa. Assume the density of the air is constant between A and B.

Determine the density of the air between A and B.

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

[Total: 11]

77. 9702_m19_qp_22 Q: 3

Two balls, X and Y, move along a horizontal frictionless surface, as illustrated in Fig. 3.1.

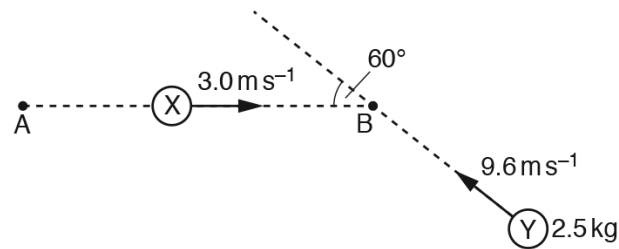


Fig. 3.1 (not to scale)

Ball X has an initial velocity of 3.0 m s^{-1} in a direction along line AB. Ball Y has a mass of 2.5 kg and an initial velocity of 9.6 m s^{-1} in a direction at an angle of 60° to line AB.

The two balls collide at point B. The balls stick together and then travel along the horizontal surface in a direction at right-angles to the line AB, as shown in Fig. 3.2.

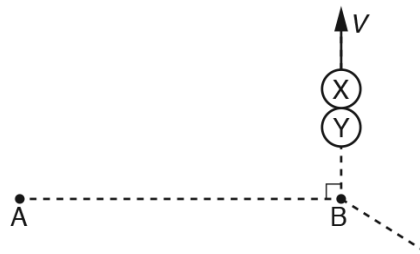


Fig. 3.2

- (a) By considering the components of momentum in the direction from A to B, show that ball X has a mass of 4.0 kg .

[2]

- (b) Calculate the common speed V of the two balls after the collision.

$V = \dots\dots\dots \text{ms}^{-1}$ [2]

- (c) Determine the difference between the initial kinetic energy of ball X and the initial kinetic energy of ball Y.

difference in kinetic energy = $\dots\dots\dots \text{J}$ [2]

[Total: 6]

78. 9702_s19_qp_22 Q: 3

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

.....
[1]

- (b) A uniform square sign with sides of length 0.68 m is fixed at its corner points A and B to a wall. The sign is also supported by a wire CD, as shown in Fig. 3.1.

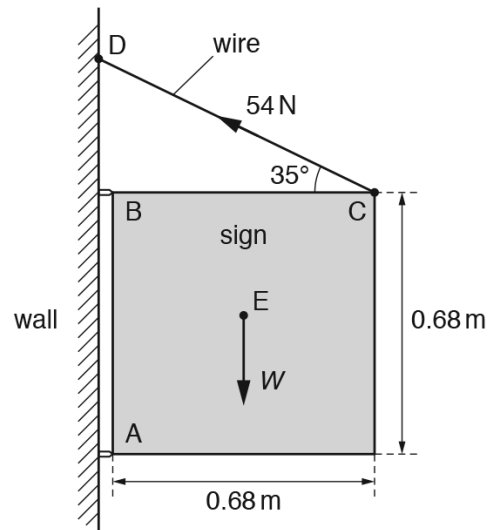


Fig. 3.1 (not to scale)

The sign has weight W and centre of gravity at point E. The sign is held in a vertical plane with side BC horizontal. The wire is at an angle of 35° to side BC. The tension in the wire is 54 N.

The force exerted on the sign at B is only in the vertical direction.

- (i) Calculate the vertical component of the tension in the wire.

vertical component of tension = ... N [1]

- (ii) Explain why the force on the sign at B does not have a moment about point A.

.....
[1]

- (iii) By taking moments about point A, show that the weight W of the sign is 150 N.

[2]

- (iv) Calculate the total vertical force exerted by the wall on the sign at points A and B.

total vertical force = ... N [1]

- (c) The sign in (b) is held together by nuts and bolts. One of the nuts falls vertically from rest through a distance of 4.8 m to the pavement below. The nut lands on the pavement with a speed of 9.2 m s^{-1} .

Determine, for the nut falling from the sign to the pavement, the ratio

$$\frac{\text{change in gravitational potential energy}}{\text{final kinetic energy}}.$$

ratio = ... [4]

[Total: 10]

79. 9702_s19_qp_23 Q: 2

- (a) A resultant force F moves an object of mass m through distance s in a straight line. The force gives the object an acceleration a so that its speed changes from initial speed u to final speed v .

(i) State an expression for:

1. the work W done by the force, in terms of a , m and s

$$W = \dots\dots\dots [1]$$

2. the distance s , in terms of a , u and v .

$$s = \dots\dots\dots [1]$$

(ii) Use your answers in (i) to show that the kinetic energy of the object is given by

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times (\text{speed})^2.$$

Explain your working.

[2]

- (b) A ball of mass 0.040 kg is projected into the air from horizontal ground, as illustrated in Fig. 2.1.

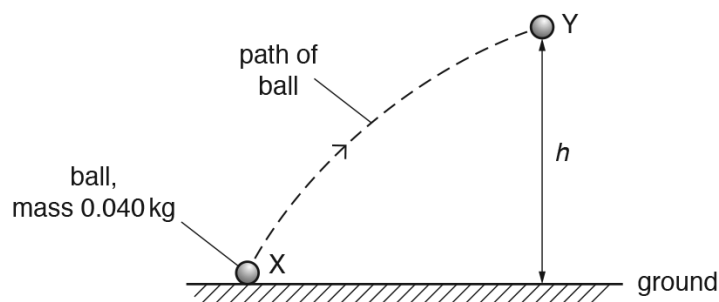


Fig. 2.1

The ball is launched from a point X with a kinetic energy of 4.5 J . At point Y, the ball has a speed of 9.5 m s^{-1} . Air resistance is negligible.

(i) For the movement of the ball from X to Y, draw a solid line on Fig. 2.1 to show:

1. the distance moved (label this line D)
2. the displacement (label this line S).

[2]

(ii) By consideration of energy transfer, determine the height h of point Y above the ground.

$h = \dots\dots\dots$ m [3]

(iii) On Fig. 2.2, sketch the variation of the kinetic energy of the ball with its vertical height above the ground for the movement of the ball from X to Y. Numerical values are not required.

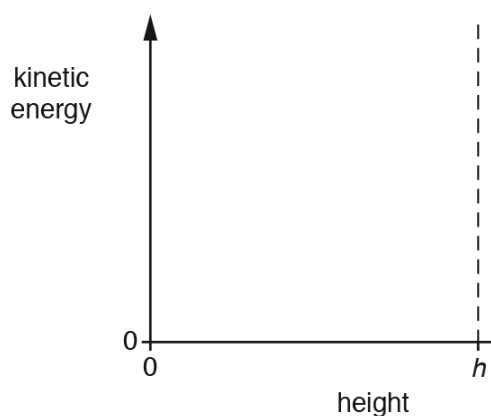


Fig. 2.2

[2]

[Total: 11]

80. 9702_w19_qp_21 Q: 4

The variation with extension x of the force F applied to a spring is shown in Fig. 4.1.

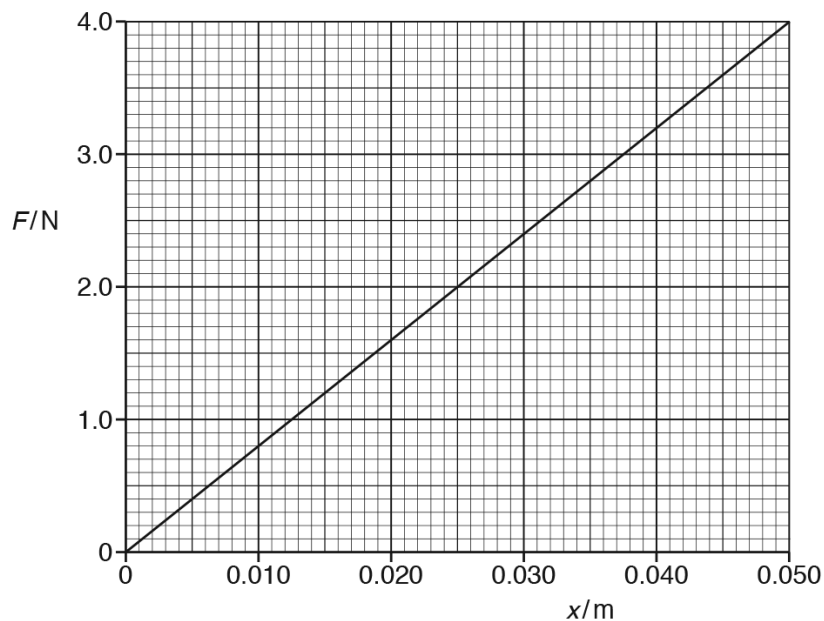


Fig. 4.1

The spring has an unstretched length of 0.080 m and is suspended vertically from a fixed point, as shown in Fig. 4.2.

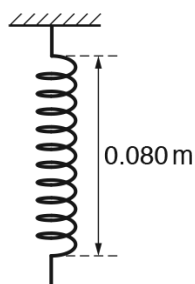


Fig. 4.2

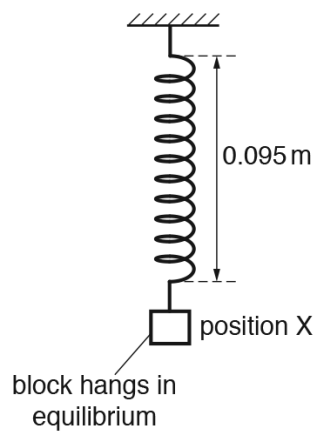


Fig. 4.3

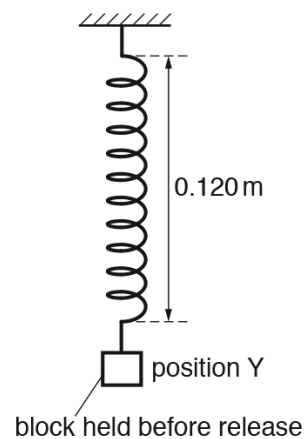


Fig. 4.4

A block is attached to the lower end of the spring. The block hangs in equilibrium at position X when the length of the spring is 0.095 m, as shown in Fig. 4.3.

The block is then pulled vertically downwards and held at position Y so that the length of the spring is 0.120 m, as shown in Fig. 4.4. The block is then released and moves vertically upwards from position Y back towards position X.

- (a) Use Fig. 4.1 to determine the spring constant of the spring.

spring constant = ... Nm^{-1} [2]

- (b) Use Fig. 4.1 to show that the decrease in elastic potential energy of the spring is 0.055 J when the block moves from position Y to position X.

[2]

- (c) The block has a mass of 0.122 kg. Calculate the increase in gravitational potential energy of the block for its movement from position Y to position X.

increase in gravitational potential energy = ... J [2]

- (d) Use the decrease in elastic potential energy stated in (b) and your answer in (c) to determine, for the block, as it moves through position X:

- (i) its kinetic energy

kinetic energy = ... J [1]

- (ii) its speed.

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

[Total: 9]

81. 9702_w19_qp_22 Q: 3

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

.....

.....

..... [2]

- (b) A block X of mass
- m_X
- slides in a straight line along a horizontal frictionless surface, as shown in Fig. 3.1.

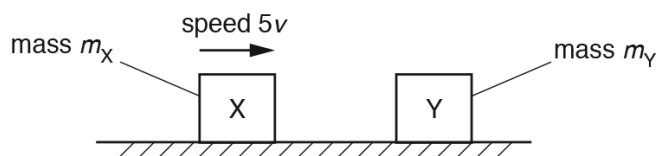


Fig. 3.1

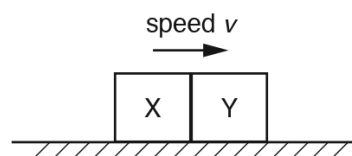


Fig. 3.2

The block X, moving with speed $5v$, collides head-on with a stationary block Y of mass m_Y . The two blocks stick together and then move with common speed v , as shown in Fig. 3.2.

- (i) Use conservation of momentum to show that the ratio
- $\frac{m_Y}{m_X}$
- is equal to 4.

[2]

- (ii) Calculate the ratio

$$\frac{\text{total kinetic energy of X and Y after collision}}{\text{total kinetic energy of X and Y before collision}}.$$

ratio = ... [3]

- (iii) State the value of the ratio in (ii) for a perfectly elastic collision.

ratio = ... [1]

- (c) The variation with time t of the momentum of block X in (b) is shown in Fig. 3.3.

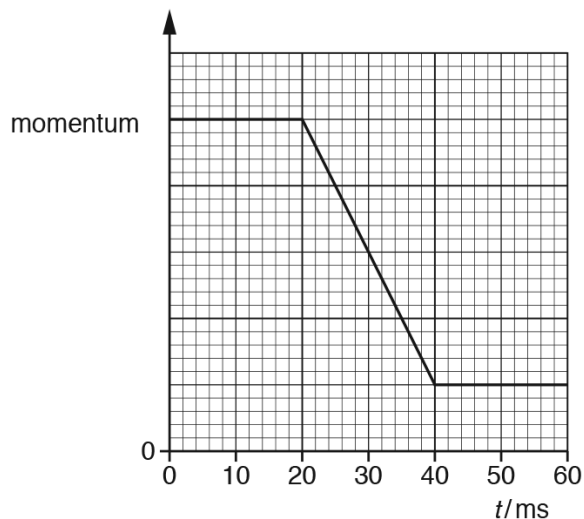


Fig. 3.3

Block X makes contact with block Y at time $t = 20$ ms.

- (i) Describe, qualitatively, the magnitude and direction of the resultant force, if any, acting on block X in the time interval:

1. $t = 0$ to $t = 20$ ms

.....

2. $t = 20$ ms to $t = 40$ ms.

.....

..... [3]

- (ii) On Fig. 3.3, sketch the variation of the momentum of block Y with time t from $t = 0$ to $t = 60$ ms. [3]

[Total: 14]

82. 9702_m18_qp_22 Q: 2

(a) Explain what is meant by

(i) *work done*,

.....
[1]

(ii) *kinetic energy*.

.....
[1]

(b) A leisure-park ride consists of a carriage that moves along a railed track. Part of the track lies in a vertical plane and follows an arc XY of a circle of radius 13 m, as shown in Fig. 2.1.

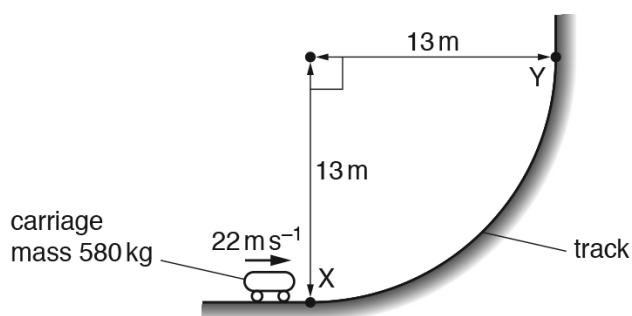


Fig. 2.1

The mass of the carriage is 580 kg. At point X, the carriage has velocity 22 m s^{-1} in a horizontal direction. The velocity of the carriage then decreases to 12 m s^{-1} in a vertical direction at point Y.

(i) For the carriage moving from X to Y

1. show that the decrease in kinetic energy is $9.9 \times 10^4 \text{ J}$,

[2]

2. calculate the gain in gravitational potential energy.

gain in gravitational potential energy = ... J [2]

- (ii) Show that the length of the track from X to Y is 20 m.

[1]

- (iii) Use your answers in (b)(i) and (b)(ii) to calculate the average resistive force acting on the carriage as it moves from X to Y.

resistive force = ... N [2]

- (iv) Describe the change in the direction of the linear momentum of the carriage as it moves from X to Y.

.....

.....[1]

- (v) Determine the magnitude of the change in linear momentum when the carriage moves from X to Y.

change in momentum = ... N s [3]

[Total: 13]

83. 9702_s18_qp_22 Q: 2

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

.....

.....

.....[2]

- (b) A stationary firework explodes into three different fragments that move in a horizontal plane, as illustrated in Fig. 2.1.

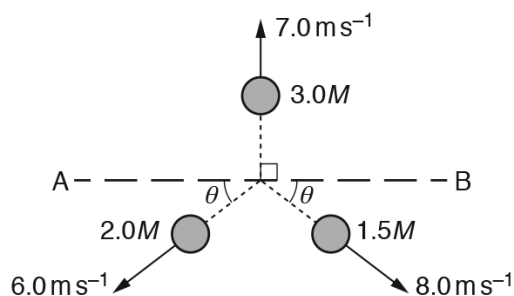


Fig. 2.1

The fragment of mass $3.0M$ has a velocity of 7.0 m s^{-1} perpendicular to line AB.

The fragment of mass $2.0M$ has a velocity of 6.0 m s^{-1} at angle θ to line AB.

The fragment of mass $1.5M$ has a velocity of 8.0 m s^{-1} at angle θ to line AB.

- (i) Use the principle of conservation of momentum to determine
- θ
- .

$$\theta = \dots\dots\dots^\circ [3]$$

- (ii) Calculate the ratio

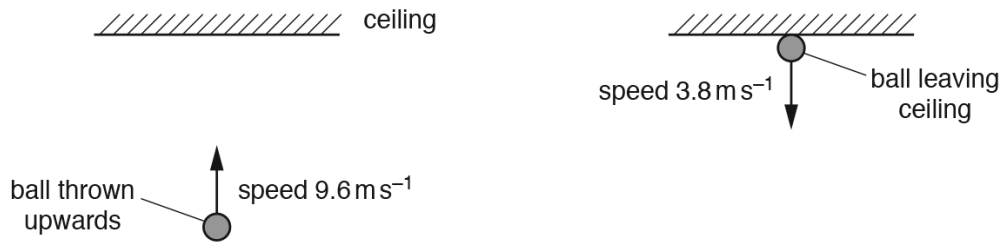
$$\frac{\text{kinetic energy of fragment of mass } 2.0M}{\text{kinetic energy of fragment of mass } 1.5M}$$

$$\text{ratio} = \dots\dots\dots [2]$$

[Total: 7]

84. 9702_s18_qp_23 Q: 3

A ball is thrown vertically upwards towards a ceiling and then rebounds, as illustrated in Fig. 3.1.

**Fig. 3.1**

The ball is thrown with speed 9.6 m s^{-1} and takes a time of 0.37 s to reach the ceiling. The ball is then in contact with the ceiling for a further time of 0.085 s until leaving it with a speed of 3.8 m s^{-1} . The mass of the ball is 0.056 kg . Assume that air resistance is negligible.

- (a) Show that the ball reaches the ceiling with a speed of 6.0 m s^{-1} .

[1]

- (b) Calculate the height of the ceiling above the point from which the ball was thrown.

height = ... m [2]

- (c) Calculate

- (i) the increase in gravitational potential energy of the ball for its movement from its initial position to the ceiling,

increase in gravitational potential energy = ... J [2]

- (ii) the decrease in kinetic energy of the ball while it is in contact with the ceiling.

decrease in kinetic energy = ... J [2]

- (d) State how Newton's third law applies to the collision between the ball and the ceiling.

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

- (e) Calculate the change in momentum of the ball during the collision.

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

- (f) Determine the magnitude of the average force exerted by the ceiling on the ball during the collision.

average force = ... N [2]

[Total: 13]

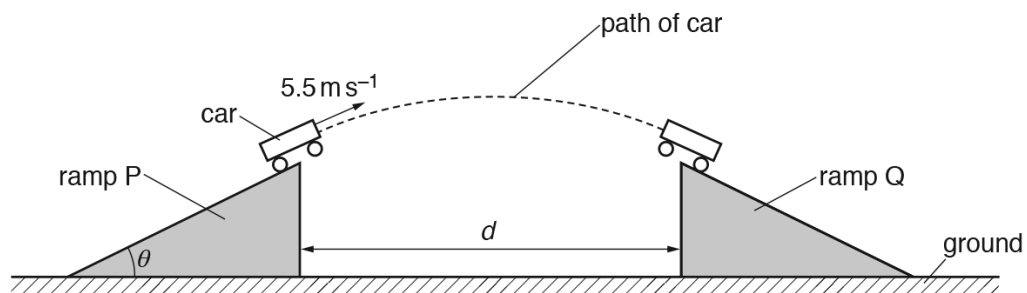
85. 9702_w18_qp_21 Q: 1

(a) Define**(i)** *displacement*,

.....
 [1]

(ii) *acceleration*.

.....
 [1]

(b) A remote-controlled toy car moves up a ramp and travels across a gap to land on another ramp, as illustrated in Fig. 1.1.**Fig. 1.1**

The car leaves ramp P with a velocity of 5.5 m s^{-1} at an angle θ to the horizontal. The horizontal component of the car's velocity as it leaves the ramp is 4.6 m s^{-1} . The car lands at the top of ramp Q. The tops of both ramps are at the same height and are distance d apart. Air resistance is negligible.

(i) Show that the car leaves ramp P with a vertical component of velocity of 3.0 m s^{-1} .

[1]

(ii) Determine the time taken for the car to travel between the ramps.

time taken = ... s [2]

- (iii) Calculate the horizontal distance d between the tops of the ramps.

$$d = \dots\dots\dots \text{ m [1]}$$

- (iv) Calculate the ratio

$$\frac{\text{kinetic energy of the car at its maximum height}}{\text{kinetic energy of the car as it leaves ramp P}}.$$

$$\text{ratio} = \dots\dots\dots [3]$$

- (c) Ramp Q is removed. The car again leaves ramp P as in (b) and now lands directly on the ground. The car leaves ramp P at time $t = 0$ and lands on the ground at time $t = T$.

On Fig. 1.2, sketch the variation with time t of the vertical component v_y of the car's velocity from $t = 0$ to $t = T$. Numerical values of v_y and t are not required.

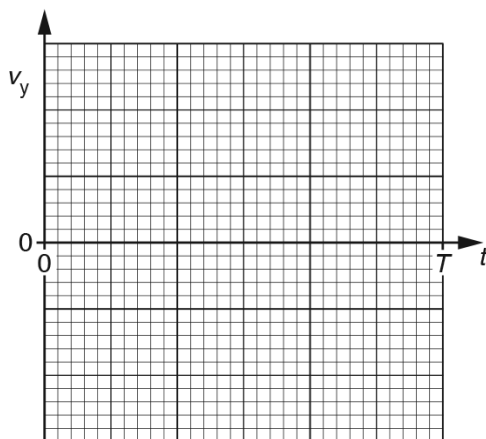


Fig. 1.2

[2]

[Total: 11]

86. 9702_w18_qp_22 Q: 1

A golfer strikes a ball so that it leaves horizontal ground with a velocity of 6.0 m s^{-1} at an angle θ to the horizontal, as illustrated in Fig. 1.1.

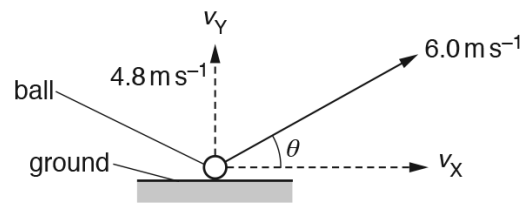


Fig. 1.1 (not to scale)

The magnitude of the initial vertical component v_y of the velocity is 4.8 m s^{-1} . Assume that air resistance is negligible.

(a) Show that the magnitude of the initial horizontal component v_x of the velocity is 3.6 m s^{-1} .

[1]

- (b) The ball leaves the ground at time $t = 0$ and reaches its maximum height at $t = 0.49$ s.

On Fig. 1.2, sketch separate lines to show the variation with time t , until the ball returns to the ground, of

- (i) the vertical component v_y of the velocity (label this line Y), [2]
 (ii) the horizontal component v_x of the velocity (label this line X). [2]

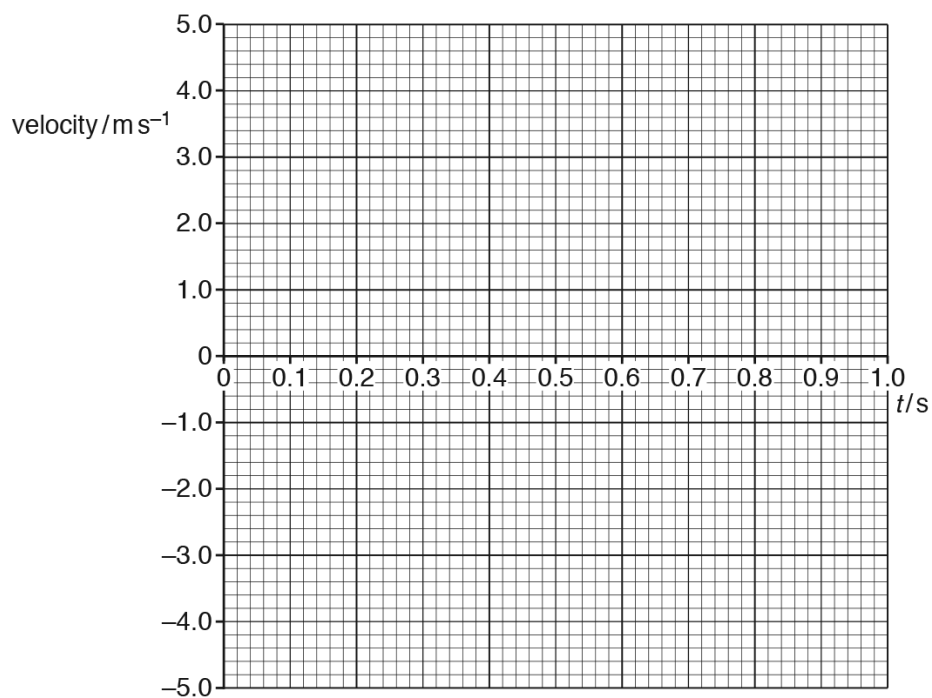


Fig. 1.2

- (c) Calculate the maximum height reached by the ball.

maximum height = ... m [2]

- (d) For the movement of the ball from the ground to its maximum height, determine the ratio
- $$\frac{\text{kinetic energy at maximum height}}{\text{change in gravitational potential energy}}.$$

ratio = ...[4]

- (e) In practice, significant air resistance acts on the ball. Explain why the actual time taken for the ball to reach maximum height is less than the time calculated when air resistance is assumed to be negligible.

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

[Total: 12]

87. 9702_w18_qp_23 Q: 2

- (a) State what is meant by *kinetic energy*.

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

- (b) A cannon fires a shell vertically upwards. The shell leaves the cannon with a speed of 80 ms^{-1} and a kinetic energy of 480 J. The shell then rises to a maximum height of 210 m. The effect of air resistance is significant.

- (i) Show that the mass of the shell is 0.15 kg.

[2]

- (ii) For the movement of the shell from the cannon to its maximum height, calculate

1. the gain in gravitational potential energy,

gain in gravitational potential energy = ... J [2]

2. the work done against air resistance.

work done = ... J [1]

- (iii) Determine the average force due to the air resistance acting on the shell as it moves from the cannon to its maximum height.

force = ... N [2]

- (iv) The shell leaves the cannon at time $t = 0$ and reaches maximum height at time $t = T$.

On Fig. 2.1, sketch the variation with time t of the velocity v of the shell from time $t = 0$ to time $t = T$. Numerical values of v and t are not required.

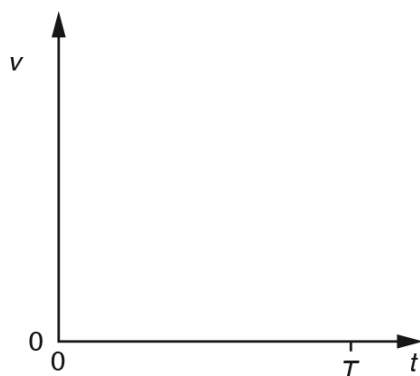


Fig. 2.1

[2]

- (v) The force due to the air resistance is a vector quantity.

Compare the force due to the air resistance acting on the shell as it rises with the force due to the air resistance as it falls.

.....

.....

.....

.....

.....[2]

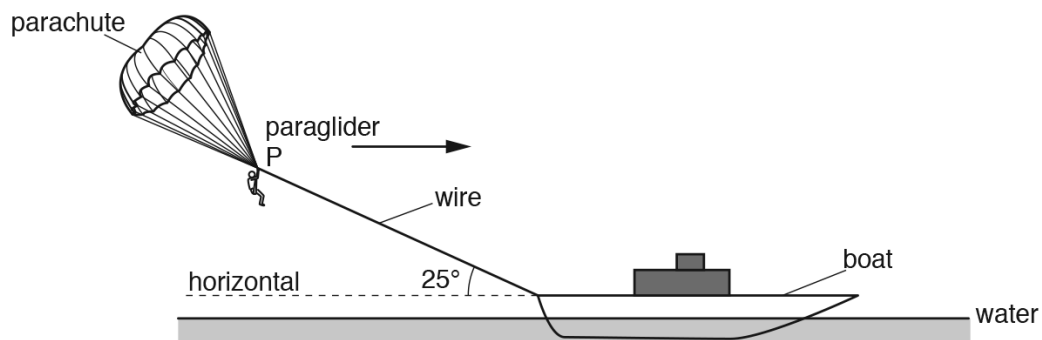
[Total: 12]

88. 9702_s17_qp_21 Q: 2

(a) State the two conditions for a system to be in equilibrium.

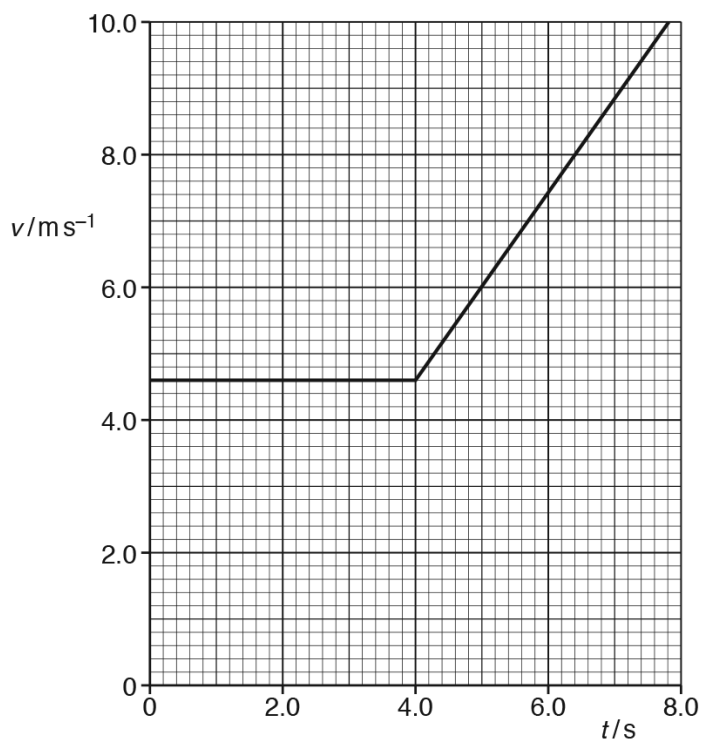
1.
-
2.
-

[2]

(b) A paraglider P of mass 95 kg is pulled by a wire attached to a boat, as shown in Fig. 2.1.**Fig. 2.1**

The wire makes an angle of 25° with the horizontal water surface. P moves in a straight line parallel to the surface of the water.

The variation with time t of the velocity v of P is shown in Fig. 2.2.

**Fig. 2.2**

- (i) Show that the acceleration of P is 1.4 m s^{-2} at time $t = 5.0 \text{ s}$.

[2]

- (ii) Calculate the total distance moved by P from time $t = 0$ to $t = 7.0 \text{ s}$.

distance = ...m [2]

- (iii) Calculate the change in kinetic energy of P from time $t = 0$ to $t = 7.0 \text{ s}$.

change in kinetic energy = ...J [2]

- (iv) The tension in the wire at time $t = 5.0 \text{ s}$ is 280 N .

Calculate, for the horizontal motion,

1. the vertical lift force F supporting P,

$F = \dots\dots\dots \text{ N}$ [3]

2. the force R due to air resistance acting on P in the horizontal direction.

$R = \dots\dots\dots \text{ N}$ [3]

[Total: 14]

89. 9702_s17_qp_22 Q: 2

(a) Define *velocity*.

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

(b) A ball of mass 0.45 kg leaves the edge of a table with a horizontal velocity v , as shown in Fig. 2.1.

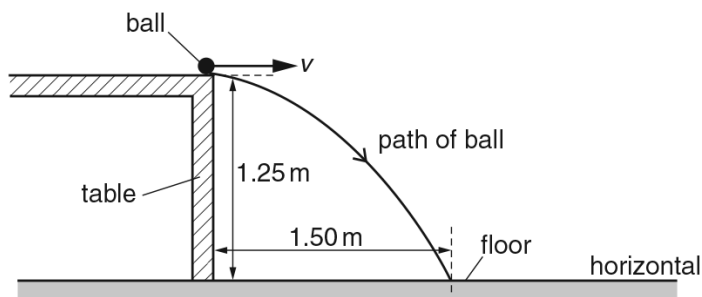


Fig. 2.1

The height of the table is 1.25 m. The ball travels a distance of 1.50 m horizontally before hitting the floor.

Air resistance is negligible.

Calculate, for the ball,

(i) the horizontal velocity v as it leaves the table,

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

(ii) the velocity just as it hits the floor,

magnitude of velocity = ... m s^{-1}

angle to the horizontal = ... $^{\circ}$
[4]

(iii) the kinetic energy just as it hits the floor,

kinetic energy = ...J [2]

(iv) the loss in gravitational potential energy as it falls from the table to the floor.

loss in potential energy = ...J [2]

(c) Explain why the kinetic energy of the ball in **(b)(iii)** does not equal the loss of gravitational potential energy in **(b)(iv)**.

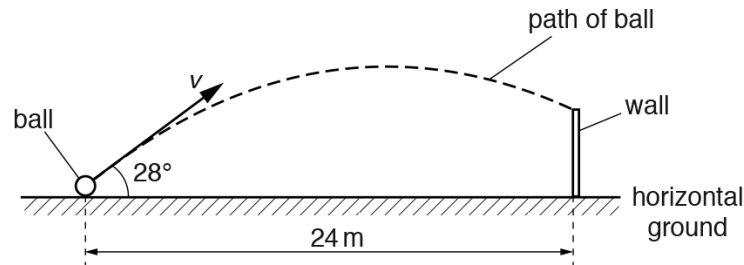
.....
.....[1]

[Total: 13]

90. 9702_m16_qp_22 Q: 2

(a) Define *acceleration*.

.....
 [1]

(b) A ball is kicked from horizontal ground towards the top of a vertical wall, as shown in Fig. 2.1.**Fig. 2.1** (not to scale)

The horizontal distance between the initial position of the ball and the base of the wall is 24 m. The ball is kicked with an initial velocity v at an angle of 28° to the horizontal. The ball hits the top of the wall after a time of 1.5 s. Air resistance may be assumed to be negligible.

(i) Calculate the initial horizontal component v_x of the velocity of the ball.

$$v_x = \dots\dots\dots \text{ms}^{-1} \quad [1]$$

(ii) Show that the initial vertical component v_y of the velocity of the ball is 8.5 ms^{-1} .

[2]

(iii) Calculate the time taken for the ball to reach its maximum height above the ground.

$$\text{time} = \dots\dots\dots \text{s} \quad [2]$$

- (iv) The ball is kicked at time $t = 0$. On Fig. 2.2, sketch the variation with time t of the vertical component v_y of the velocity of the ball until it hits the wall. It may be assumed that velocity is positive when in the upwards direction.

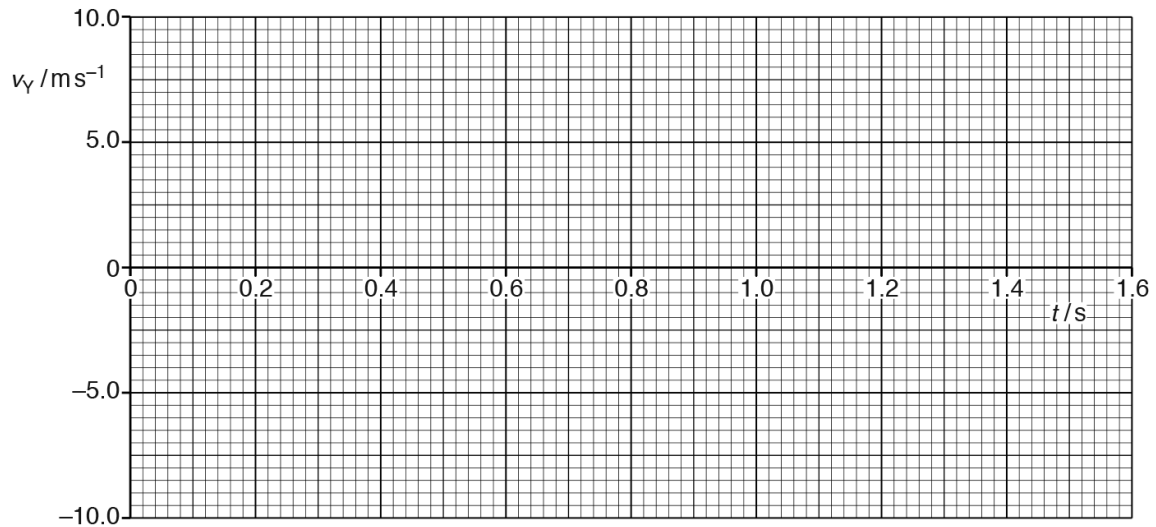


Fig. 2.2

[2]

- (c) (i) Use the information in (b) to determine the maximum height of the ball above the ground.

maximum height = ... m [2]

- (ii) The maximum gravitational potential energy of the ball above the ground is 22 J. Calculate the mass of the ball.

mass = ... kg [2]

- (d) A ball of greater mass is kicked with the same velocity as the ball in (b). State and explain the effect, if any, of the increased mass on the maximum height reached by the ball. Air resistance is still assumed to be negligible.

.....

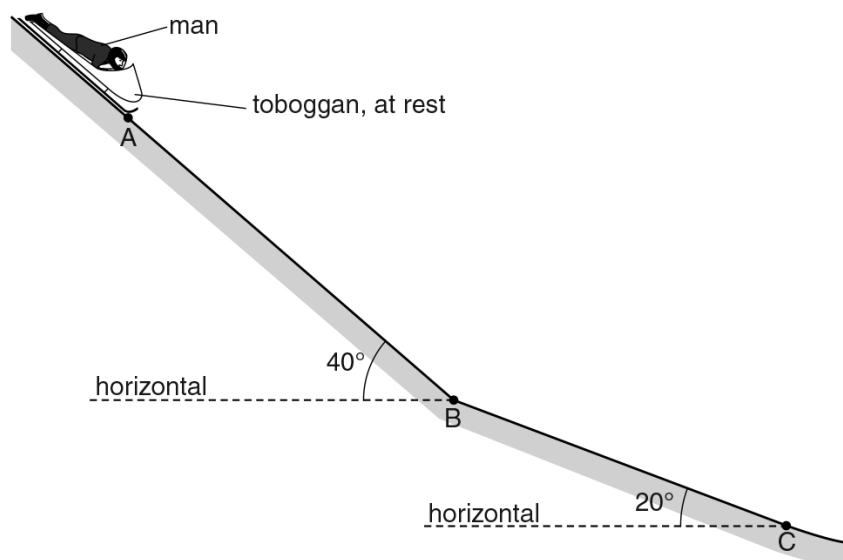
..... [1]

[Total: 13]

91. 9702_s16_qp_22 Q: 1

(a) Define *acceleration*.

.....
[1]

(b) A man travels on a toboggan down a slope covered with snow from point A to point B and then to point C. The path is illustrated in Fig. 1.1.**Fig. 1.1** (not to scale)

The slope AB makes an angle of 40° with the horizontal and the slope BC makes an angle of 20° with the horizontal. Friction is not negligible.

The man and toboggan have a combined mass of 95 kg.

The man starts from rest at A and has constant acceleration between A and B. The man takes 19 s to reach B. His speed is 36 ms^{-1} at B.

(i) Calculate the acceleration from A to B.

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

(ii) Show that the distance moved from A to B is 340 m.

[1]

(iii) For the man and toboggan moving from A to B, calculate

1. the change in kinetic energy,

change in kinetic energy = ... J [2]

2. the change in potential energy.

change in potential energy = ... J [2]

(iv) Use your answers in **(iii)** to determine the average frictional force that acts on the toboggan between A and B.

frictional force = ... N [2]

(v) A parachute opens on the toboggan as it passes point B. There is a constant deceleration of 3.0 m s^{-2} from B to C.

Calculate the frictional force that produces this deceleration between B and C.

frictional force = ... N [2]

[Total: 12]

92. 9702_s16_qp_23 Q: 3

- (a) Explain what is meant by *gravitational potential energy* and by *kinetic energy*.

gravitational potential energy:

.....

kinetic energy:

.....

[2]

- (b) A motion sensor is used to measure the velocity of a ball falling vertically towards the ground, as illustrated in Fig. 3.1.

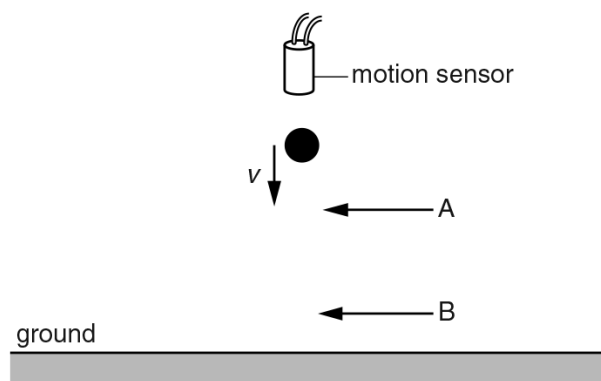


Fig. 3.1

The ball passes through points A and B as it falls. The ball has a mass of 1.5 kg.

The variation with time t of the velocity v of the ball as it falls from A to B is shown in Fig. 3.2.

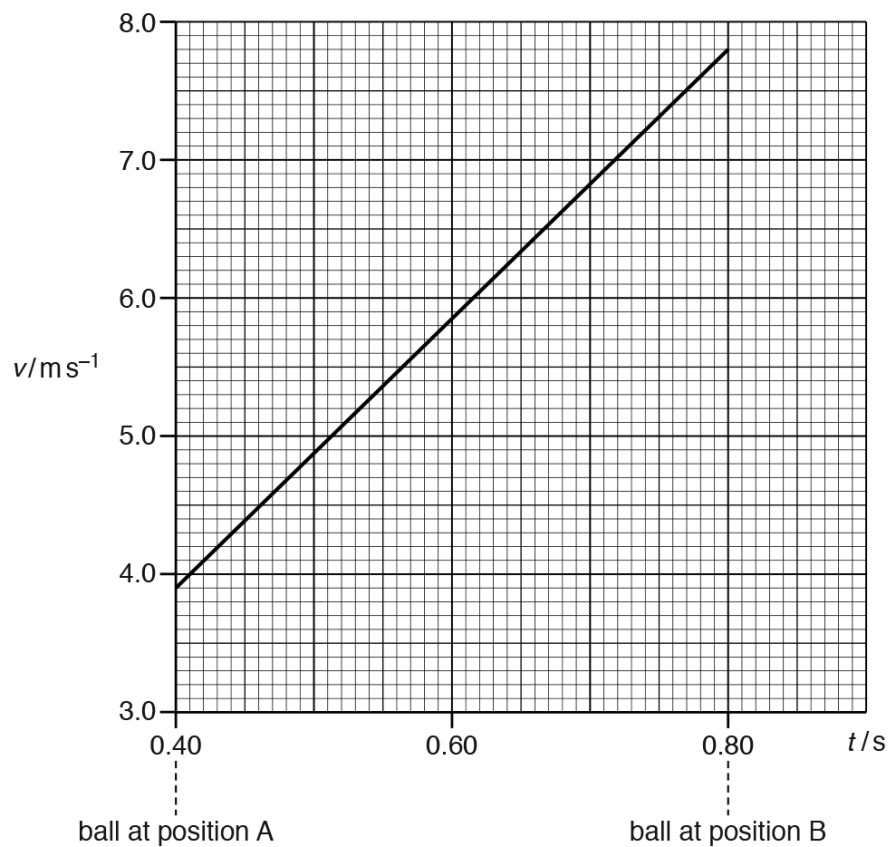


Fig. 3.2

Use Fig. 3.2 to calculate, for the ball falling from A to B,

(i) the displacement,

displacement = ...m [3]

(ii) the acceleration,

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

(iii) the change in kinetic energy.

change in kinetic energy = ...J [3]

- (c) Show that the work done by the gravitational field on the ball in (b) as it moves from A to B is equal to the change in kinetic energy.

[2]

[Total: 12]

93. 9702_w16_qp_22 Q: 2

A ball of mass 0.030 kg moves along a curved track, as shown in Fig. 2.1.

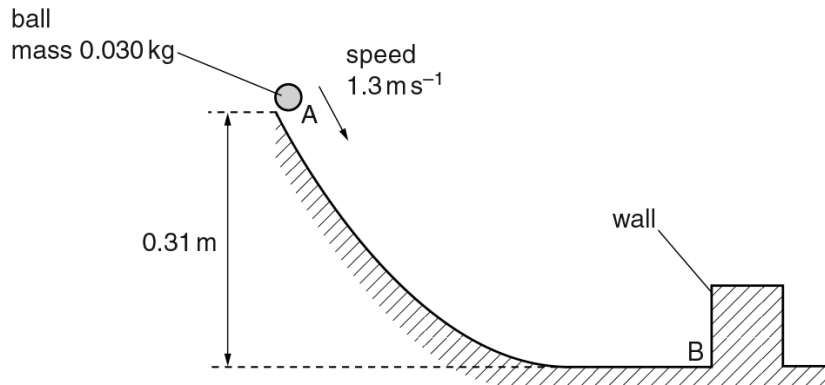


Fig. 2.1

The speed of the ball is 1.3 m s^{-1} when it is at point A at a height of 0.31 m . The ball moves down the track and collides with a vertical wall at point B. The ball then rebounds back up the track. It may be assumed that frictional forces are negligible.

- (a)** Calculate the change in gravitational potential energy of the ball in moving from point A to point B.

change in gravitational potential energy = ... J [2]

- (b)** Show that the ball hits the wall at B with a speed of 2.8 m s^{-1} .

[3]

- (c) The change in momentum of the ball due to the collision with the wall is $0.096 \text{ kg m s}^{-1}$. The ball is in contact with the wall for a time of 20 ms.

Determine, for the ball colliding with the wall,

- (i) the speed immediately after the collision,

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

- (ii) the magnitude of the average force on the ball.

force = ... N [2]

- (d) State and explain whether the collision is elastic or inelastic.

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

- (e) In practice, frictional effects are significant so that the actual increase in kinetic energy of the ball in moving from A to B is 76 mJ. The length of the track between A and B is 0.60 m.

Use your answer in (a) to determine the average frictional force acting on the ball as it moves from A to B.

frictional force = ... N [2]

[Total: 12]

94. 9702_s15_qp_23 Q: 2

The variation with time t of the velocity v of a ball is shown in Fig. 2.1.

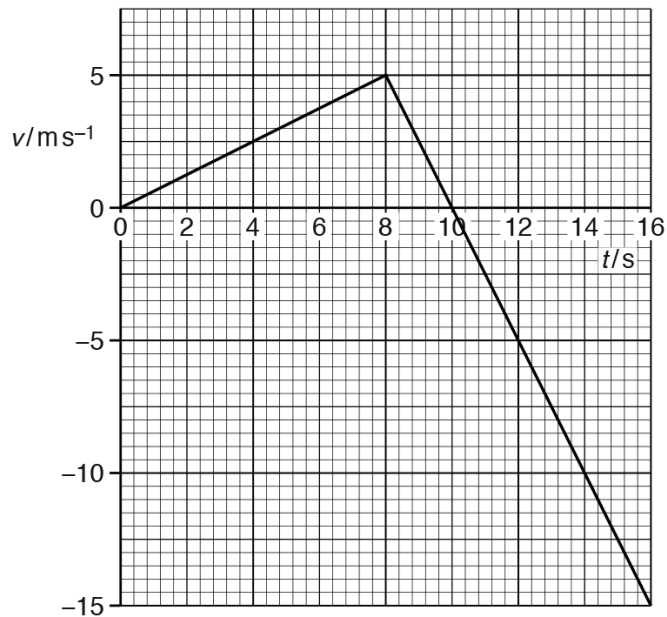


Fig. 2.1

The ball moves in a straight line from a point P at $t = 0$. The mass of the ball is 400 g.

(a) Use Fig. 2.1 to describe, without calculation, the velocity of the ball from $t = 0$ to $t = 16$ s.

.....

.....

.....

.....

.....[2]

(b) Use Fig. 2.1 to calculate, for the ball,

(i) the displacement from P at $t = 10$ s,

displacement = ... m [2]

(ii) the acceleration at $t = 10$ s,

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

(iii) the maximum kinetic energy.

kinetic energy = ... J [2]

(c) Use your answers in **(b)(i)** and **(b)(ii)** to determine the time from $t = 0$ for the ball to return to P.

time = ... s [2]

95. 9702_w15_qp_21 Q: 3

- (a) An object is moved from point P to point R either by a direct path or by the path P to Q to R, as shown in Fig. 3.1.

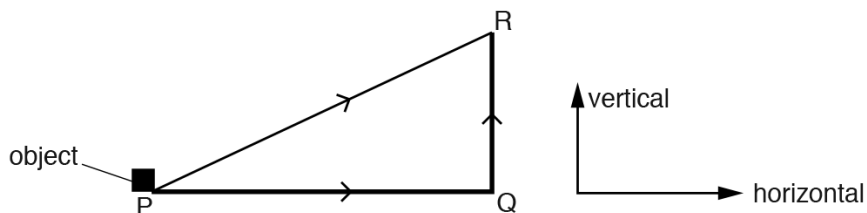


Fig. 3.1

P and Q are on the same horizontal level. R is vertically above Q.

Explain whether the work done moving the object against the gravitational field is the same or different along paths PR and PQR.

.....

[2]

- (b) A ball is thrown with an initial velocity V at an angle θ to the horizontal, as shown in Fig. 3.2.

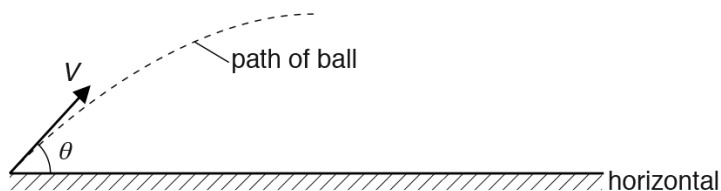


Fig. 3.2 (not to scale)

The variation with time t of the height h of the ball is shown in Fig. 3.3.

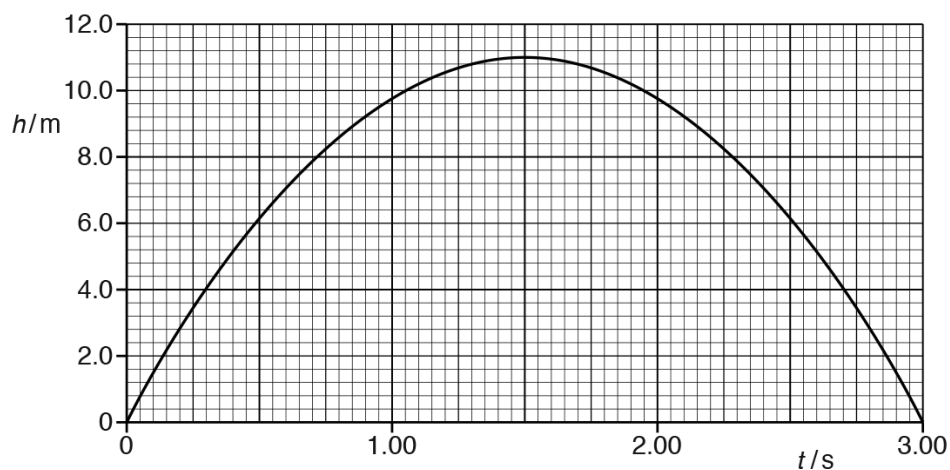


Fig. 3.3

- (i) Use the time to reach maximum height to determine the vertical component V_v of the velocity of the ball for time $t = 0$.

$$V_v = \dots\dots\dots \text{ms}^{-1} \quad [2]$$

- (ii) The horizontal displacement of the ball at $t = 3.00\text{s}$ is 25.5m .
On Fig. 3.4, draw the variation with t of the horizontal displacement x of the ball.

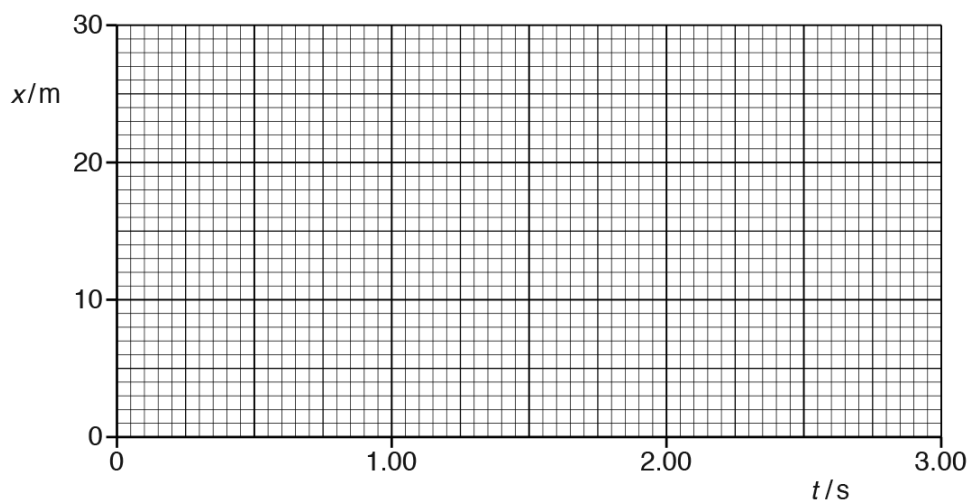


Fig. 3.4

[1]

- (iii) For the ball at maximum height, calculate the ratio

$$\frac{\text{potential energy of the ball}}{\text{kinetic energy of the ball}}.$$

$$\text{ratio} = \dots\dots\dots [3]$$

- (iv) In practice, air resistance is not negligible. State and explain the effect of air resistance on the time taken for the ball to reach maximum height.

.....

 [2]

96. 9702_w15_qp_22 Q: 2

Fig. 2.1 shows an object M on a slope.

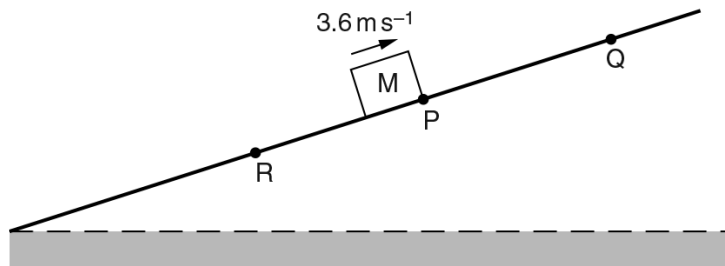


Fig. 2.1

M moves up the slope, comes to rest at point Q and then moves back down the slope to point R. M has a constant acceleration of 3.0 m s^{-2} down the slope at all times. At time $t = 0$, M is at point P and has a velocity of 3.6 m s^{-1} up the slope. The total distance from P to Q and then to R is 6.0 m .

(a) Calculate, for the motion of M from P to Q,

(i) the time taken,

time = ... s [2]

(ii) the distance travelled.

distance = ... m [1]

(b) Show that the speed of M at R is 4.8 m s^{-1} .

(c) On Fig. 2.2, draw the variation with time t of the velocity v of M for the motion P to Q to R.

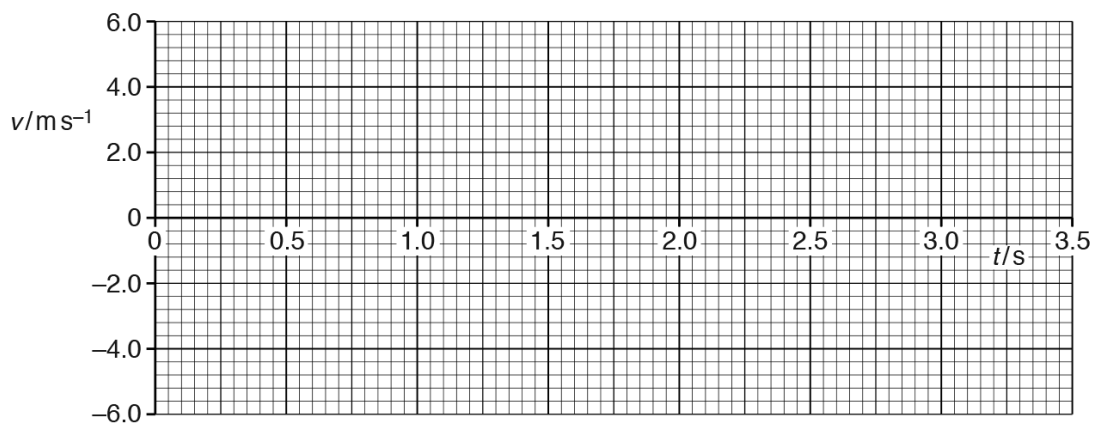


Fig. 2.2

[3]

(d) The mass of M is 450 g.

Calculate the difference in the kinetic energy of M at P and at R.

difference in kinetic energy = ... J [2]

97. 9702_w15_qp_23 Q: 3

A steel ball falls from a platform on a tower to the ground below, as shown in Fig. 3.1.

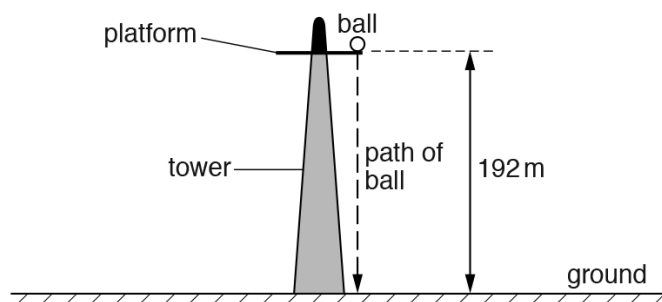


Fig. 3.1

The ball falls from rest through a vertical distance of 192 m. The mass of the ball is 270 g.

(a) Assume air resistance is negligible.

(i) Calculate

1. the time taken for the ball to fall to the ground,

time taken = ...s [2]

2. the maximum kinetic energy of the ball.

maximum kinetic energy = ...J [2]

(ii) State and explain the variation of the velocity of the ball with time as the ball falls to the ground.

.....
[1]

(iii) Show that the velocity of the ball on reaching the ground is approximately 60 m s^{-1} .

[1]

- (b) In practice, air resistance is not negligible. The variation of the air resistance R with the velocity v of the ball is shown in Fig. 3.2.

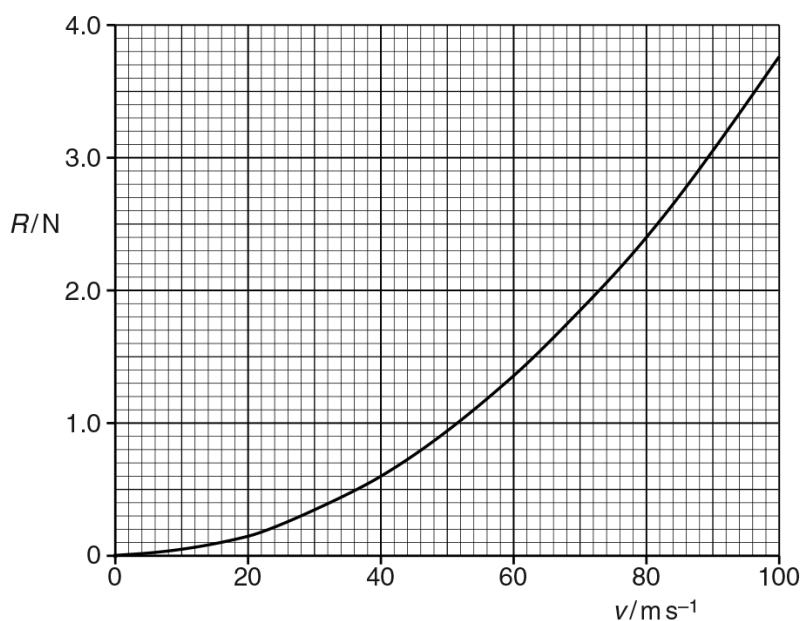


Fig. 3.2

- (i) Use Fig. 3.2 to state and explain qualitatively the variation of the acceleration of the ball with the distance fallen by the ball.

.....

[3]

- (ii) The speed of the ball reaches 40 ms^{-1} . Calculate its acceleration at this speed.

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

- (iii) Use information from (a)(iii) and Fig. 3.2 to state and explain whether the ball reaches terminal velocity.

.....

[2]

6.4 Power

98. 9702_s20_qp_22 Q: 1

- (a) Define *velocity*.

.....
 [1]

- (b) The drag force F_D acting on a car moving with speed v along a straight horizontal road is given by

$$F_D = v^2 Ak$$

where k is a constant and A is the cross-sectional area of the car.

Determine the SI base units of k .

SI base units [2]

- (c) The value of k , in SI base units, for the car in (b) is 0.24. The cross-sectional area A of the car is 5.1 m^2 .

The car is travelling with a constant speed along a straight road and the output power of the engine is $4.8 \times 10^4 \text{ W}$. Assume that the output power of the engine is equal to the rate at which the drag force F_D is doing work against the car.

Determine the speed of the car.

speed = ... ms^{-1} [3]

[Total: 6]

99. 9702_s19_qp_23 Q: 3

A cylindrical disc of mass 0.24 kg has a circular cross-sectional area A , as shown in Fig. 3.1.

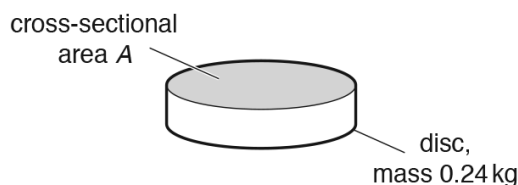


Fig. 3.1

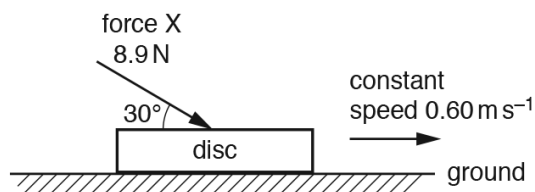


Fig. 3.2

The disc is on horizontal ground, as shown in Fig. 3.2. A force X of magnitude 8.9 N acts on the disc in a direction of 30° to the horizontal. The disc moves at a constant speed of 0.60 m s^{-1} along the ground.

- (a) Determine the rate of doing work on the disc by the force X .

rate of doing work = ... W [2]

- (b) The force X and the weight of the disc exert a combined pressure on the ground of 3500 Pa .

Calculate the cross-sectional area A of the disc.

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

- (c) Newton's third law describes how forces exist in pairs. One such pair of forces is the weight of the disc and another force Y . State:

- (i) the direction of force Y

.....[1]

- (ii) the name of the body on which force Y acts.

.....[1]

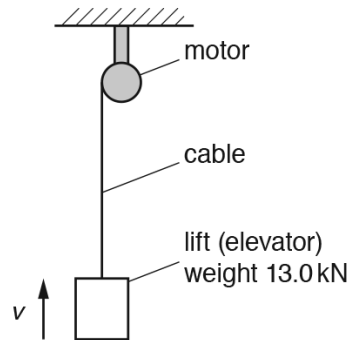
[Total: 7]

100. 9702_w19_qp_23 Q: 2

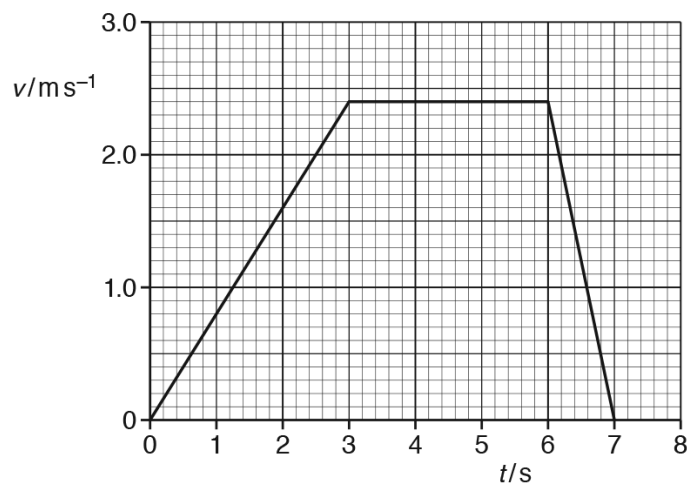
(a) State what is meant by *work done*.

.....

..... [1]

(b) A lift (elevator) of weight 13.0 kN is connected by a cable to a motor, as shown in Fig. 2.1.**Fig. 2.1**

The lift is pulled up a vertical shaft by the cable. A constant frictional force of 2.0 kN acts on the lift when it is moving. The variation with time t of the speed v of the lift is shown in Fig. 2.2.

**Fig. 2.2**

(i) Use Fig. 2.2 to determine:

1. the acceleration of the lift between time $t = 0$ and $t = 3.0$ s

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

2. the work done by the motor to raise the lift between time $t = 3.0$ s and $t = 6.0$ s.

work done = ... J [2]

- (ii) The motor has an efficiency of 67%. The tension in the cable is $1.6 \times 10^4 \text{ N}$ at time $t = 2.5$ s.

Determine the input power to the motor at this time.

input power = ... W [3]

- (iii) State and explain whether the increase in gravitational potential energy of the lift from time $t = 0$ to $t = 7.0$ s is less than, the same as, or greater than the work done by the motor. A calculation is not required.

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

[Total: 9]

101. 9702_w18_qp_21 Q: 3

(a) (i) Define *power*.

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

(ii) State what is meant by *gravitational potential energy*.

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

(b) An aircraft of mass 1200 kg climbs upwards with a constant velocity of 45 m s^{-1} , as shown in Fig. 3.1.

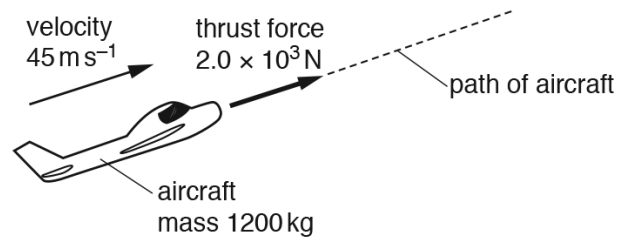


Fig. 3.1 (not to scale)

The aircraft's engine produces a thrust force of $2.0 \times 10^3\text{ N}$ to move the aircraft through the air. The rate of increase in height of the aircraft is 3.3 m s^{-1} .

(i) Calculate the power produced by the thrust force.

power = ... W [2]

(ii) Determine, for a time interval of 3.0 minutes,

1. the work done by the thrust force to move the aircraft,

work done = ... J [2]

2. the increase in gravitational potential energy of the aircraft,

increase in gravitational potential energy = ... J [2]

3. the work done against air resistance.

work done = ... J [1]

(iii) Use your answer in **(b)(ii) part 3** to calculate the force due to air resistance acting on the aircraft.

force = ... N [1]

(iv) With reference to the motion of the aircraft, state and explain whether the aircraft is in equilibrium.

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

[Total: 12]

102. 9702_m17_qp_22 Q: 3

(a) Define *velocity*.

.....

.....[1]

(b) A car travels in a straight line up a slope, as shown in Fig. 3.1.

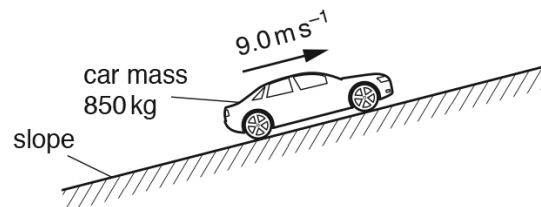


Fig. 3.1

The car has mass 850 kg and travels with a constant speed of 9.0 ms^{-1} . The car's engine exerts a force on the car of 2.0 kN up the slope.

A resistive force F_D , due to friction and air resistance, opposes the motion of the car.

The variation of F_D with the speed v of the car is shown in Fig. 3.2.

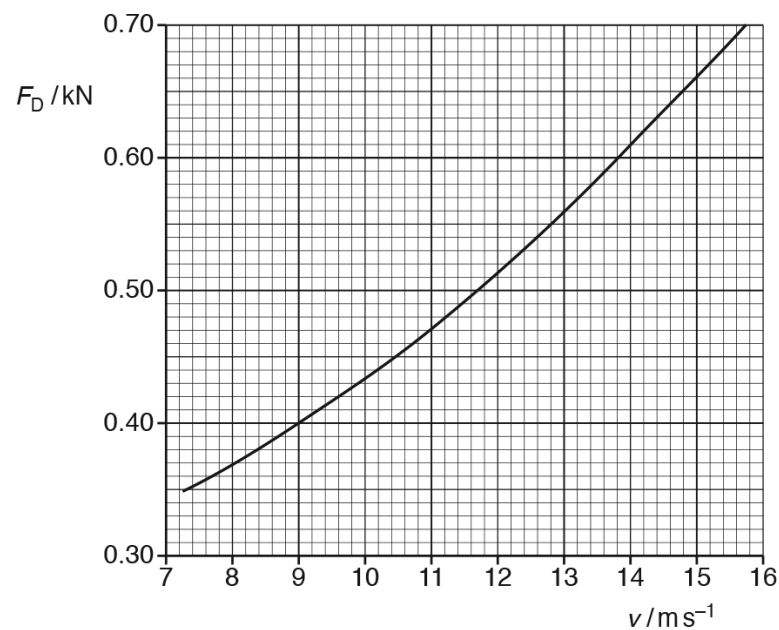


Fig. 3.2

- (i) State and explain whether the car is in equilibrium as it moves up the slope.

.....

[2]

- (ii) Consider the forces that act along the slope. Use data from Fig. 3.2 to determine the component of the weight of the car that acts down the slope.

component of weight = ... N [2]

- (iii) Show that the power output of the car is $1.8 \times 10^4 \text{ W}$.

[2]

- (iv) The car now travels along horizontal ground. The output power of the car is maintained at $1.8 \times 10^4 \text{ W}$. The variation of the resistive force F_D acting on the car is given in Fig. 3.2.

Calculate the acceleration of the car when its speed is 15 m s^{-1} .

acceleration = ... m s^{-2} [3]

[Total: 10]

103. 9702_s15_qp_23 Q: 3

(a) Define *power*.

.....
[1]

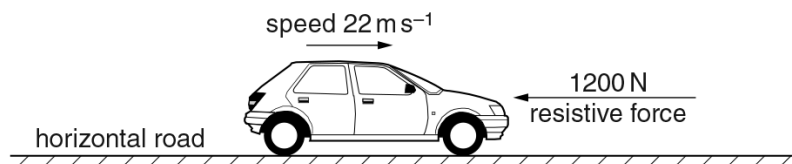
(b) Fig. 3.1 shows a car travelling at a speed of 22 m s^{-1} on a horizontal road.

Fig. 3.1

The car has a mass of 1500 kg . A resistive force of 1200 N acts on the car.

Calculate

(i) the force F required from the car to produce an acceleration of 0.82 m s^{-2} ,

$F = \dots\dots\dots\text{ N}$ [3]

(ii) the power required to produce this acceleration.

power = $\dots\dots\dots\text{ W}$ [2]

(c) The resistive force on the car is proportional to v^2 , where v is the speed of the car. Suggest why the car has a maximum speed.

.....
[1]

67. 9702_w15_qp_23 Q: 7

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

C1

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

A1 [2]

(b) $\rho = m/V$

C1

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

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

C1

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

A1

or

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

(C1)

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

(C1)

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

(A1)

or

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

(C1)

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

(C1)

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

(A1) [3]

68. 9702_s20_qp_21 Q: 2

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

69. 9702_s17_qp_22 Q: 4

	Answer	Mark
(a)	a body/mass/object continues (at rest or) at constant/uniform velocity unless acted on by a resultant force	B1
(b)(i)	initial momentum = final momentum	C1
	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$	
	$0.60 \times 100 - 0.80 \times 200 = -0.40 \times 100 + v \times 200$ $v = (-) 0.3(0) \text{ m s}^{-1}$	A1
(b)(ii)	<u>kinetic</u> energy is not conserved/is lost (but) <u>total</u> energy is conserved/constant or some of the (initial) <u>kinetic</u> energy is transformed into other forms of energy	B1

70. 9702_w17_qp_23 Q: 2

	Answer	Mark
(a)	$\rho = m / V$ or $\rho = m / Ah$	B1
	$p = F / A$ or $p = W / A$	B1
	$p = [\rho Ahg] / A$ or $p = [\rho Vg] / [V / h]$ (so) $p = \rho gh$	A1

	Answer	Mark
(b)(i)	1. weight/gravitational (force) upthrust (force)/buoyancy (force) drag/viscous/frictional (force)/fluid resistance/resistance	B1
	2. weight = upthrust + viscous (force)	B1
(b)(ii)	- decrease in (gravitational) potential energy (of sphere) due to decrease in height (since $E_p = mgh$) - increase in thermal energy due to work done against viscous force/drag - loss/change of (total) E_p equal to gain/change in thermal energy Any 2 points.	B2
(c)(i)	atmospheric pressure = $9.1(0) \times 10^4 \text{ Pa}$	A1
(c)(ii)	$(\Delta)p = \rho g(\Delta)h$ $(9.15 - 9.10) \times 10^4 = \rho \times 9.81 \times (0.17 - 0.10)$	C1
	$\rho = 730 \text{ (728) kg m}^{-3}$	A1

71. 9702_s15_qp_22 Q: 2

- (a) speed decreases/stone decelerates to rest/zero at 1.25 s B1
 speed then increases/stone accelerates (in opposite direction) B1 [2]
- (b) (i) $v = u + at$ (or $s = ut + \frac{1}{2}at^2$ and $v^2 = u^2 + 2as$) C1
 $= 0 + (3.00 - 1.25) \times 9.81$ C1
 $= 17.2 \text{ (17.17) ms}^{-1}$ A1 [3]
- (ii) $s = ut + \frac{1}{2}at^2$
 $s = \frac{1}{2} \times 9.81 \times (1.25)^2 [= 7.66]$ C1
 $s = \frac{1}{2} \times 9.81 \times (1.75)^2 [= 15.02]$ C1
 (distance = 7.66 + 15.02)
 $[v = u + at = 0 + 9.81 \times (2.50 - 1.25) = 12.26 \text{ ms}^{-1}]$
 or
 $s = \frac{1}{2} \times 9.81 \times (1.25)^2 [= 7.66]$ (C1)
 $s = 12.26 \times 0.50 + \frac{1}{2} \times 9.81 \times (3.00 - 2.50)^2 [= 7.36]$ (C1)
 (distance = 2 × 7.66 + 7.36)
Example alternative method:
 $s = (v^2 - u^2)/2a = (12.26^2 - 0)/2 \times 9.81 [= 7.66]$ (C1)
 $s = (v^2 - u^2)/2a = (17.17^2 - 12.26^2)/2 \times 9.81 [= 7.36]$ (C1)
 (distance = 2 × 7.66 + 7.36)
 22.7 (22.69 or 23) m A1 [3]
- (iii) $(s = 15.02 - 7.66 =) 7.4 \text{ (7.36) m}$ (ignore sign in answer) A1
 down A1 [2]
- (c) straight line from positive value of v to t axis M1
 same straight line crosses t axis at $t = 1.25 \text{ s}$ A1
 same straight line continues with same gradient to $t = 3.0 \text{ s}$ A1 [3]

72. 9702_w15_qp_23 Q: 4

- (a) (i) reaction/vertical force = weight – $P \cos 60^\circ$ C1
 $= 180 - 35 \cos 60^\circ$
 $= 160$ (163) N A1 [2]
- (ii) work done = $35 \sin 60^\circ \times 20$ C1
 $= 610$ (606) J A1 [2]
- (b) (i) work done by force P = work done against frictional force B1 [1]
- (ii) horizontal component of P is equal and opposite to frictional force B1
vertical component of P + normal reaction force equal and opposite to weight B1 [2]

73. 9702_s20_qp_21 Q: 3

	Answer	Mark
(a)	resultant force (in any direction) is zero	B1
	resultant torque/moment (about any point) is zero	B1
(b)(i)	1. $T \sin 53^\circ = 2.4$ $T = 3.0$ N	A1
	2. $F = T \cos 53^\circ$ or $F^2 = T^2 - 2.4^2$ $F = 1.8$ N	A1
(b)(ii)	$\sigma = T/A$ or $\sigma = F/A$	C1
	$A = \pi d^2/4$ or $A = \pi r^2$	C1
	$\sigma = 3.0 \times 4 / [\pi \times (0.50 \times 10^{-3})^2]$ $= 1.5 \times 10^7$ Pa	A1
(c)(i)	$h = 75 - 75 \sin 53^\circ = 15$ cm	A1
(c)(ii)	$(\Delta)E = mg(\Delta)h$ or $(\Delta)E = W(\Delta)h$	C1
	$(\Delta)E = 2.4 \times 15 \times 10^{-2}$ $= 0.36$ J	A1
(c)(iii)	$E = \frac{1}{2}mv^2$	B1
	$0.36 = \frac{1}{2} \times (2.4/9.81) \times v^2$	C1
	$v = 1.7$ m s ⁻¹	A1

74. 9702_s20_qp_22 Q: 3

	Answer	Mark
(a)	(work done =) force $\times$ displacement in direction of the force	B1
(b)(i)	1. $(\Delta)E = mg(\Delta)h$	C1
	$= 0.42 \times 9.81 \times 78$	A1
	$= 320 \text{ J}$	
	2. $E = \frac{1}{2}mv^2$	C1
(b)(ii)	$(\Delta)E = \frac{1}{2} \times 0.42 \times 23^2$	A1
	$= 110 \text{ J}$	
(b)(ii)	work done = $320 - 110 (= 210 \text{ N})$	C1
	average resistive force = $210 / 78$	A1
	$= 2.7 \text{ N}$	
(c)	downward sloping line from (0, g) to a non-zero value on the time axis	M1
	line is curved with a gradient that becomes less negative and the line meets t -axis at time $t < T$	A1

75. 9702_w20_qp_21 Q: 2

	Answer	Mark
(a)	constant gradient	B1
(b)	(displacement until 0.20 s =) $\frac{1}{2} \times 1.96 \times 0.20 (= 0.196 \text{ m})$	C1
	or (displacement after 0.20 s =) $\frac{1}{2} \times 6.86 \times 0.70 (= 2.401 \text{ m})$	
	height = $2.401 - 0.196$	C1
	$= 2.2 \text{ m}$ <i>(alternative methods are possible using equations of uniformly accelerated motion)</i>	A1
(c)	$(\Delta)E = mg(\Delta)h$ or $W(\Delta)h$	C1
	$(\Delta)E = 0.86 \times 2.2$	A1
	$= 1.9 \text{ J}$	
(d)	curved line from the origin	M1
	gradient of curved line decreases and is zero at $t = 0.20 \text{ s}$ only	A1
(e)	acceleration (of free fall) is unchanged/is not dependent on mass <u>and</u> (so) no effect	B1

76. 9702_m19_qp_22 Q: 2

	Answer	Mark
(a)(i)	distance in a specified direction (from a point)	B1
(a)(ii)	change in velocity / time (taken)	B1
(b)(i)	constant velocity so no resultant force	B1
	no resultant force so in equilibrium	B1
(b)(ii)	(difference in height =) $47 \times 2.8 \times 60 \times \sin 24^\circ = 3200 \text{ m}$	A1

	Answer	Mark
(b)(iii)	1 $(\Delta)E = mg(\Delta)h$ $= 85 \times 9.81 \times 3200$	C1
	$= 2.7 \times 10^6 \text{ J}$	A1
	2 <u>In terms of energy:</u> work done $= 2.7 \times 10^6 \text{ J}$ force $= 2.7 \times 10^6 / (47 \times 2.8 \times 60)$	C1
	$= 340 \text{ N}$	A1
	<u>In terms of forces:</u> component of weight along path = force due to air resistance force $= 85 \times 9.81 \times \sin 24^\circ$	(C1)
	$= 340 \text{ N}$	(A1)
(b)(iv)	$(\Delta)p = \rho g(\Delta)h$ $(92 - 63) \times 10^3 = \rho \times 9.81 \times 3200$	C1
	$\rho = 0.92 \text{ kg m}^{-3}$	A1

77. 9702_m19_qp_22 Q: 3

	Answer	Mark
(a)	$(m \times 3.0) \text{ or } (2.5 \times 9.6 \times \cos 60^\circ)$	C1
	$(m \times 3.0) - (2.5 \times 9.6 \times \cos 60^\circ) = 0 \text{ so } m = 4.0 \text{ (kg)}$	A1

	Answer	Mark
(b)	$2.5 \times 9.6 \times \sin 60^\circ = (4.0 + 2.5) \times V$	C1
	$V = 3.2 \text{ m s}^{-1}$	A1
	or use of momentum vector triangle: $(4.0 \times 3.0)^2 + [(4.0 + 2.5) \times V]^2 = (2.5 \times 9.6)^2$	(C1)
	$V = 3.2 \text{ m s}^{-1}$	(A1)
(c)	$E = \frac{1}{2}mv^2$ difference in $E_K = \frac{1}{2} \times 2.5 \times (9.6)^2 - \frac{1}{2} \times 4.0 \times (3.0)^2$	C1
	$= 97 \text{ J}$	A1

78. 9702_s19_qp_22 Q: 3

	Answer	Mark
(a)	the point where (all) the weight (of the body) is taken to act	B1
(b)(i)	vertical component = $54 \sin 35^\circ$ = 31 N	A1
(b)(ii)	the (line of action of the) force (at B) passes through (point) A or the (line of action of the) force (at B) has zero (perpendicular) distance from (point) A	B1
(b)(iii)	$54 \sin 35^\circ \times 0.68$ or $54 \cos 35^\circ \times 0.68$ or $W \times 0.34$	C1
	$54 \sin 35^\circ \times 0.68 + 54 \cos 35^\circ \times 0.68 = W \times 0.34$ so $W = 150$ (N)	A1
(b)(iv)	total vertical force = $150 - 31$ = 120 N	A1
(c)	$(\Delta)E = mg(\Delta)h$	C1
	$E = \frac{1}{2}mv^2$	C1
	ratio = $(m \times 9.81 \times 4.8) / (\frac{1}{2} \times m \times 9.2^2)$ or $(9.81 \times 4.8) / (\frac{1}{2} \times 9.2^2)$	C1
	= 1.1	A1

79. 9702_s19_qp_23 Q: 2

	Answer	Mark
(a)(i)	1. $W = mas$	B1
	2. $s = (v^2 - u^2) / 2a$	B1
(a)(ii)	W/work equals energy transferred/gain or change in kinetic energy	B1
	$W (= mas) = ma(v^2 - u^2) / 2a$	B1
	leading to $W = m(v^2 - u^2) / 2$ (so $KE = \frac{1}{2}mv^2$)	
(b)(i)	1. solid curved line drawn from X to Y along path of ball and labelled D	B1
	2. solid straight line drawn from X to Y and labelled S	B1
(b)(ii)	$(\Delta)E = mg(\Delta)h$	C1
	$4.5 = (0.040 \times 9.81 \times h) + (\frac{1}{2} \times 0.040 \times 9.5^2)$	C1
	$h = 6.9$ m	A1
(b)(iii)	line with a negative gradient starting from a non-zero value of kinetic energy when the vertical height is zero	M1
	straight line ends at a non-zero value of kinetic energy when the vertical height is h	A1

80. 9702_w19_qp_21 Q: 4

	Answer	Mark
(a)	$k = F/x$ or $k = \text{gradient}$	C1
	e.g. $k = 4.0 / 0.050$	A1
	$k = 80 \text{ N m}^{-1}$	
(b)	$E = \frac{1}{2}Fx$ or $E = \frac{1}{2}kx^2$ or $E = \text{area under graph}$	C1
	$(\Delta)E = (\frac{1}{2} \times 3.2 \times 0.040) - (\frac{1}{2} \times 1.2 \times 0.015) = 0.055 \text{ J}$ or $(\Delta)E = (\frac{1}{2} \times 80 \times 0.040^2) - (\frac{1}{2} \times 80 \times 0.015^2) = 0.055 \text{ J}$ or $(\Delta)E = \frac{1}{2} \times (1.2 + 3.2) \times 0.025 = 0.055 \text{ J}$	A1
	$(\Delta)E = mg(\Delta)h$	C1
	$= 0.122 \times 9.81 \times (0.120 - 0.095)$ $= 0.030 \text{ J}$	A1
(c)	or	
	$(\Delta)E = W \times (\Delta)h$	(C1)
	$= 1.2 \times 0.025$	(A1)
	$= 0.030 \text{ J}$	

	Answer	Mark
(d)(i)	$E = 0.055 - 0.030$	A1
	$= 0.025 \text{ J}$	
(d)(ii)	$E = \frac{1}{2}mv^2$	C1
	$v = [(2 \times 0.025) / 0.122]^{0.5}$	A1
	$= 0.64 \text{ m s}^{-1}$	

81. 9702_w19_qp_22 Q: 3

	Answer	Mark
(a)	force on body A (by body B) is equal (in magnitude) to force on body B (by body A)	B1
	force on body A (by body B) is opposite (in direction) to force on body B (by body A)	B1
(b)(i)	$m_X \times 5v$ or $(m_X + m_Y) \times v$	C1
	$m_X \times 5v = (m_X + m_Y) \times v$ (so) $m_Y / m_X = 4$	A1
(b)(ii)	$(E =) \frac{1}{2}mv^2$	C1
	ratio $= [\frac{1}{2} \times (m_X + m_Y) \times v^2] / [\frac{1}{2} \times m_X \times (5v)^2]$	C1
	$= 0.2$	A1
(b)(iii)	ratio = 1	A1
(c)(i)	1. (magnitude of resultant force is) zero	B1
	2. (magnitude of resultant force is) constant	B1
	(direction of resultant force is) opposite to the momentum	B1
(c)(ii)	horizontal line from (0 ms, 0 squares) ending at (20 ms, 0 squares)	B1
	straight line from (20 ms, 0 squares) ending at (40 ms, 4.0 squares [= 4.0 cm vertically])	B1
	horizontal line from (40 ms, 4.0 squares) ending at (60 ms, 4.0 squares)	B1

82. 9702_m18_qp_22 Q: 2

	Answer	Mark
(a)(i)	force $\times$ distance <u>moved</u> in the direction of the force	B1
(a)(ii)	energy (of a mass/body) due to motion / speed / velocity	B1
(b)(i)	1 $E = \frac{1}{2}mv^2$	C1
	$(\Delta)E = \frac{1}{2} \times 580 \times (22^2 - 12^2) = 9.9 \times 10^4 \text{ J}$	A1
	2 $(\Delta)E = mg(\Delta)h$ $\Delta E = 580 \times 9.81 \times 13$	C1
	$= 7.4 \times 10^4 \text{ J}$	A1

	Answer	Mark
(b)(ii)	length $= (2\pi \times 13) / 4$ or $(\pi \times 26) / 4$ or $(\pi \times 13) / 2 = 20 \text{ m}$	A1
(b)(iii)	work done against resistive force $= 9.9 \times 10^4 - 7.4 \times 10^4$ average resistive force $= (9.9 \times 10^4 - 7.4 \times 10^4) / 20$	C1
	$= 1300 \text{ N}$	A1
(b)(iv)	from horizontal/right to vertical / up or 90°	A1
(b)(v)	$p = mv$ or (580×22) or (580×12)	C1
	$\Delta p = [(580 \times 12)^2 + (580 \times 22)^2]^{0.5}$	C1
	$= 1.5 \times 10^4 \text{ N s}$	A1

83. 9702_s18_qp_22 Q: 2

	Answer	Mark
(a)	<u>sum/total</u> momentum (of a system of bodies) is constant or <u>sum/total</u> momentum before $=$ <u>sum/total</u> momentum after	M1
	for an isolated system or no (resultant) external force	A1
(b)(i)	$(p =) mv$ or $(3.0M \times 7.0)$ or $(2.0M \times 6.0)$ or $(1.5M \times 8.0)$	C1
	$3.0M \times 7.0 = 2.0M \times 6.0 \sin \theta + 1.5M \times 8.0 \sin \theta$	C1
	$\theta = 61^\circ$	A1
	or (vector triangle method)	
	momentum vector triangle drawn	(C1)
	$\theta = 61^\circ$ (2 marks for $\pm 1^\circ$, 1 mark for $\pm 2^\circ$)	(A2)
	or (use of cosine rule)	
	$p = mv$ or $(3.0M \times 7.0)$ or $(2.0M \times 6.0)$ or $(1.5M \times 8.0)$	(C1)
	$(21M)^2 = (12M)^2 + (12M)^2 - (2 \times 12M \times 12M \times \cos 2\theta)$	(C1)
	$\theta = 61^\circ$	(A1)
(b)(ii)	$(E =) \frac{1}{2}mv^2$	C1
	ratio $= (\frac{1}{2} \times 2.0M \times 6.0^2) / (\frac{1}{2} \times 1.5M \times 8.0^2)$ $= 0.75$	A1

84. 9702_s18_qp_23 Q: 3

	Answer	Mark
(a)	$v = u + at$ $v = 9.6 - (9.81 \times 0.37) = 6.0 \text{ ms}^{-1}$	A1
(b)	$s = \frac{1}{2} \times (9.6 + 6.0) \times 0.37$ or $6.0^2 = 9.6^2 - (2 \times 9.81 \times s)$ or $s = (9.6 \times 0.37) - (\frac{1}{2} \times 9.81 \times 0.37^2)$ or $s = (6.0 \times 0.37) + (\frac{1}{2} \times 9.81 \times 0.37^2)$	C1
	$s = 2.9 \text{ m}$	A1
(c)(i)	$(\Delta)E = mg(\Delta)h$	C1
	$\Delta E = 0.056 \times 9.81 \times 2.9$ $= 1.6 \text{ J}$	A1
(c)(ii)	$E = \frac{1}{2}mv^2$	C1
	$\Delta E = \frac{1}{2} \times 0.056 \times (6.0^2 - 3.8^2)$ $= 0.60 \text{ J}$	A1
(d)	force on ball (by ceiling) <u>equal</u> to force on ceiling (by ball)	M1
	and opposite (in direction)	A1
(e)	$(p =) mv$ or 0.056×6.0 or 0.056×3.8	C1
	change in momentum $= 0.056 \times (6.0 + 3.8)$ $= 0.55 \text{ N s}$	A1

	Answer	Mark
(f)	resultant force $= 0.55 / 0.085 (= 6.47 \text{ N})$	C1
	force by ceiling $= 6.47 - (0.056 \times 9.81)$ $= 5.9 \text{ N}$	A1

85. 9702_w18_qp_21 Q: 1

	Answer	Mark
(a)(i)	distance in a specified direction (from a point)	B1
(a)(ii)	change in velocity / time (taken)	B1
(b)(i)	vertical component of velocity = $(5.5^2 - 4.6^2)^{1/2} = 3.0 \text{ (ms}^{-1}\text{)}$ or $5.5 \cos \theta = 4.6$ (so $\theta = 33.2^\circ$) and $5.5 \sin 33.2^\circ = 3.0 \text{ (ms}^{-1}\text{)}$	A1
(b)(ii)	$s = ut + \frac{1}{2}at^2$ $0 = (3.0 \times t) - (\frac{1}{2} \times 9.81 \times t^2)$ or $v = u + at$ $-3.0 = 3.0 - 9.81t$	C1
	$t = 0.61 \text{ s}$	A1
(b)(iii)	$d = 4.6 \times 0.61$ $= 2.8 \text{ m}$	A1
(b)(iv)	$E = \frac{1}{2}mv^2$	C1
	ratio = $(\frac{1}{2} \times m \times 4.6^2) / (\frac{1}{2} \times m \times 5.5^2)$ or ratio = $(\frac{1}{2} \times m \times 5.5^2 - m \times 9.81 \times 0.459) / (\frac{1}{2} \times m \times 5.5^2)$	C1
	ratio = 0.70	A1
(c)	straight line from positive value of v_y at $t = 0$ to negative value of v_y	M1
	straight line ends at $t = T$ and final magnitude of v_y greater than initial magnitude of v_y	A1

86. 9702_w18_qp_22 Q: 1

	Answer	Mark
(a)	$v_x = (6.0^2 - 4.8^2)^{1/2} = 3.6 \text{ (ms}^{-1}\text{)}$ or $6.0 \sin \theta = 4.8$ (so $\theta = 53.1^\circ$) and $v_x = 6.0 \cos 53.1^\circ = 3.6 \text{ (ms}^{-1}\text{)}$	A1
(b)(i)	straight line from (0, 4.8) to (0.49, 0)	M1
	straight line continues with same slope to (0.98, -4.8) (labelled Y)	A1
(b)(ii)	a horizontal line	M1
	from (0, 3.6) to (0.98, 3.6) (labelled X)	A1
(c)	$s = ut + \frac{1}{2}at^2$ $= (4.8 \times 0.49) + (\frac{1}{2} \times -9.81 \times 0.49^2)$ or $s = \frac{1}{2}(u + v)t$ or area under graph $= \frac{1}{2} \times (4.8 + 0) \times 0.49$ or $s = vt - \frac{1}{2}at^2$ $= \frac{1}{2} \times 9.81 \times 0.49^2$ or $v^2 = u^2 + 2as$ $s = 4.8^2 / (2 \times 9.81)$	C1
	$s = 1.2 \text{ m}$	A1

	Answer	Mark
(d)	$(\Delta)E = mg(\Delta)h$	C1
	$E = \frac{1}{2}mv^2$	C1
	ratio = $(\frac{1}{2} \times m \times 3.6^2) / (m \times 9.81 \times 1.2)$ or ratio = $[(\frac{1}{2} \times m \times 6.0^2) - (m \times 9.81 \times 1.2)] / (m \times 9.81 \times 1.2)$ or ratio = $(\frac{1}{2} \times m \times 3.6^2) / (\frac{1}{2} \times m \times 4.8^2)$	C1
	ratio = 0.56	A1
	(force due to) air resistance acts in opposite direction to the velocity or (with air resistance, average) resultant force is larger (than weight)	B1

87. 9702_w18_qp_23 Q: 2

	Answer	Mark
(a)	energy (of a mass/body/object) due to motion/speed/velocity	B1
(b)(i)	$E = \frac{1}{2}mv^2$	C1
	$480 = \frac{1}{2} \times m \times 80^2$ so $m = 0.15 \text{ kg}$	A1
(b)(ii)	1. $E = mgh$ or $\Delta E = mg\Delta h$	C1
	$= 0.15 \times 9.81 \times 210$ $= 310 \text{ J}$	A1
	2. work done = $480 - 310$ $= 170 \text{ J}$	A1
(b)(iii)	work done = Fs	C1
	force = $170/210$ $= 0.81 \text{ N}$	A1
(b)(iv)	curved line from positive value on v -axis to $(T, 0)$	M1
	magnitude of gradient decreases	A1
(b)(v)	as shell rises force decreases and as shell falls force increases	B1
	as shell rises force is downward and as shell falls force is upward	B1
	or	
	as shell rises the force decreases and is downward	(B1)
	as shell falls the force increases and is upward	(B1)

88. 9702_s17_qp_21 Q: 2

	Answer	Mark
(a)	resultant force (in any direction) is zero	B1
	resultant torque/moment (about any point) is zero	B1
(b)(i)	$a = (v - u) / t$ or gradient or $\Delta v / (\Delta) t$	C1
	e.g. $a = (8.8 - 4.6) / (7.0 - 4.0) = 1.4 \text{ m s}^{-2}$	A1
(b)(ii)	$s = 4.6 \times 4 + [(8.8 + 4.6) / 2] \times 3$	C1
	$= 18.4 + 20.1$	A1
	$= 39 \text{ (38.5) m}$	
(b)(iii)	$\Delta E = \frac{1}{2} \times 95 [(8.8)^2 - (4.6)^2]$	C1
	$= 3678 - 1005$	A1
	$= 2700 \text{ (2673) J}$	
(b)(iv)1.	weight $= 95 \times 9.81 (= 932 \text{ N})$	C1
	vertical tension force $= 280 \sin 25^\circ$ or $280 \cos 65^\circ (= 118.3 \text{ N})$	C1
	$F = 932 + 118$	A1
	$= 1100 \text{ (1050) N}$	
(b)(iv)2.	horizontal tension force $= 280 \cos 25^\circ$ or $280 \sin 65^\circ (= 253.8 \text{ N})$	C1
	resultant force $= 95 \times 1.4 (= 133 \text{ N})$	C1
	$133 = 253.8 - R$	A1
	$R = 120 \text{ (120.8) N}$	

89. 9702_s17_qp_22 Q: 2

	Answer	Mark
(a)	rate of change of displacement or change in displacement/time taken	B1
(b)(i)	$s = ut + \frac{1}{2}at^2$	C1
	$t = [(2 \times 1.25) / 9.81]^{1/2} (= 0.5048 \text{ s})$	C1
	or	
	$v^2 = u^2 + 2as$	(C1)
	$v_{\text{vert}} = (2 \times 9.81 \times 1.25)^{1/2} (= 4.95)$	
	$t = [2s / (u + v)] = 2 \times 1.25 / 4.95 (= 0.5048 \text{ s})$	(C1)
	$v = d / t = 1.5 / 0.50(48)$ $= 3.0 \text{ (2.97) ms}^{-1}$	A1
(b)(ii)	vertical velocity $= at$ $= 9.81 \times 0.5048 (= 4.95) \text{ [using } t = 0.50 \text{ gives } 4.9]$	C1
	velocity $= [(v_h)^2 + (v_v)^2]^{1/2}$	C1
	$= [(2.97)^2 + (4.95)^2]^{1/2}$ $= 5.8 \text{ (5.79) [using } t = 0.50 \text{ leads to } 5.7]$	A1
	direction $(= \tan^{-1} 4.95/2.97) = 59^\circ$	A1
(b)(iii)	kinetic energy $= \frac{1}{2}mv^2$	C1
	$= \frac{1}{2} \times 0.45 \times (5.8)^2$	A1
	$= 7.6 \text{ (7.57) J [using } t = 0.50 \text{ leads to } 7.3 \text{ J]}$	

	Answer	Mark
(b)(iv)	potential energy = mgh	C1
	= $(0.45 \times 9.81 \times 1.25)$	A1
	= 5.5 (5.52) J	
(c)	there is KE of the ball at the start/leaving table or the ball has an initial/constant horizontal velocity or the ball has velocity at start/leaving table	B1

90. 9702_m16_qp_22 Q: 2

- (a) change in velocity/time (taken) **or** rate of change of velocity B1
- (b) (i) $v_x = (24 / 1.5) = 16 \text{ (ms}^{-1}\text{)}$ A1
- (ii) $\tan 28^\circ = v_y / v_x$ **or** $v_x = v \cos 28^\circ$ **and** $v_y = v \sin 28^\circ$ C1
 $v_y = 16 \tan 28^\circ$ **or** $v_y = 16 \times (\sin 28^\circ / \cos 28^\circ)$ **so** $v_y = 8.5 \text{ (ms}^{-1}\text{)}$ A1
- (iii) $v = u + at$ C1
 $t = (0 - 8.5) / (-9.81)$
 $= 0.87 \text{ (s)}$ A1
- (iv) straight line from positive v_y at $t = 0$ to negative v_y at $t = 1.5 \text{ s}$ M1
line starts at $(0, 8.5)$ and crosses t -axis at $(0.87, 0)$ and does not go beyond $t = 1.5 \text{ s}$. A1
- (c) (i) $(v^2 = u^2 + 2as)$ $0 = 8.5^2 + 2(-9.81)s$
or $(s = ut + \frac{1}{2}at^2)$ $s = 8.5 \times 0.87 + \frac{1}{2} \times (-9.81) \times 0.87^2$
or $(s = vt - \frac{1}{2}at^2)$ $s = 0 - \frac{1}{2} \times (-9.81) \times 0.87^2$
or $(s = \frac{1}{2}(u + v)t$ **or** area under graph) $s = 0.5 \times 8.5 \times 0.87$ C1
 $s = 3.7 \text{ (m)}$ A1
- (ii) $\Delta E_p = mg\Delta h$ (allow $E = mgh$) C1
 $m = 22 / (9.81 \times 3.7)$
 $= 0.61 \text{ (kg)}$ A1
- (d) acceleration (of freefall) is unchanged/not dependent on mass, and so no effect (on maximum height)
or explanation in terms of energy:
(initial) KE $\propto$ mass, $(\Delta)KE = (\Delta)PE$, (max) PE $\propto$ mass, and so
no effect (on maximum height) B1

91. 9702_s16_qp_22 Q: 1

- (a) acceleration = change in velocity / time (taken) or rate of change of velocity B1 [1]
- (b) (i) $v = 0 + at$ or $v = at$ C1
- $(a = 36/19 =) 1.9 \text{ (1.8947) ms}^{-2}$ A1 [2]
- (ii) $s = \frac{1}{2}(u + v)t$ or $s = v^2/2a$ or $s = \frac{1}{2}at^2$
- $= \frac{1}{2} \times 36 \times 19 = 36^2/(2 \times 1.89) = \frac{1}{2} \times 1.89 \times 19^2$
- $= 340 \text{ m (342 m/343 m/341 m)}$ M1 [1]
- (iii) 1. $(\Delta KE =) \frac{1}{2} \times 95 \times (36)^2$ C1
- $= 62\,000 \text{ (61\,560) J}$ A1 [2]
2. $(\Delta PE =) 95 \times 9.81 \times 340 \sin 40^\circ$ or $95 \times 9.81 \times 218.5$ C1
- $= 200\,000 \text{ J}$ A1 [2]
- (iv) work done (by frictional force) = $\Delta PE - \Delta KE$
- or
- work done = $200\,000 - 62\,000$ (values from 1b(iii) 1. and 2.) C1
- (frictional force = $138\,000/340 =$) $410 \text{ (406) N [420 N if full figures used]}$ A1 [2]
- (v) $-ma = mg \sin 20^\circ - f$ or $ma = -mg \sin 20^\circ + f$ C1
- $-95 \times 3.0 = 95 \times 3.36 - f$
- $f = 600 \text{ (604) N}$ A1 [2]

92. 9702_s16_qp_23 Q: 3

- (a) (gravitational potential energy is) the energy/ability to do work of a mass that it has or is stored due to its position/height in a gravitational field B1
- kinetic energy is energy/ability to do work a object/body/mass has due to its speed/velocity/motion/movement B1 [2]
- (b) (i) $s = [(u + v)t]/2$ or acceleration = $9.8/9.75$ (using gradient) C1
- $= [(7.8 + 3.9) \times 0.4]/2$ or $s = 3.9 \times 0.4 + \frac{1}{2} \times 9.75 \times (0.4)^2$ C1
- $s = 2.3(4) \text{ m}$ A1 [3]
- (ii) $a = (v - u)/t$ or gradient of line C1
- $= (7.8 - 3.9)/0.4 = 9.8 \text{ (9.75) ms}^{-2}$ (allow $\pm \frac{1}{2}$ small square in readings) A1 [2]

(iii) $KE = \frac{1}{2}mv^2$ C1

change in kinetic energy $= \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$= \frac{1}{2} \times 1.5 \times (7.8^2 - 3.9^2)$ C1

$= 34 \text{ (34.22) J}$ A1 [3]

(c) work done = force $\times$ distance (moved) or Fd or Fx or mgh or mgd or mgx M1

$= 1.5 \times 9.8 \times 2.3 = 34 \text{ (33.8) J (equals the change in KE)}$ A1 [2]

93. 9702_w16_qp_22 Q: 2

(a) $\Delta E = mg\Delta h$ C1

$= 0.030 \times 9.81 \times (-)0.31$

$= (-)0.091 \text{ J}$ A1 [2]

(b) $E = \frac{1}{2}mv^2$ C1

(initial) $E = \frac{1}{2} \times 0.030 \times 1.3^2 (= 0.0254)$ C1

$0.5 \times 0.030 \times v^2 = (0.5 \times 0.030 \times 1.3^2) + (0.030 \times 9.81 \times 0.31)$ so $v = 2.8 \text{ ms}^{-1}$

or

$0.5 \times 0.030 \times v^2 = (0.0254) + (0.091)$ so $v = 2.8 \text{ ms}^{-1}$ A1 [3]

(c) (i) $0.096 = 0.030(v + 2.8)$ C1

$v = 0.40 \text{ ms}^{-1}$ A1 [2]

(ii) $F = \Delta p / (\Delta)t$ or $F = ma$

$= 0.096 / 20 \times 10^{-3}$ or $0.030 (0.40 + 2.8) / 20 \times 10^{-3}$ C1

$= 4.8 \text{ N}$ A1 [2]

(d) kinetic energy (of ball and wall) decreases/changes/not conserved, so inelastic
or
(relative) speed of approach (of ball and wall) not equal to/greater than (relative)
speed of separation, so inelastic. B1 [1]

(e) force = work done / distance moved

$= (0.091 - 0.076) / 0.60$ C1

$= 0.025 \text{ N}$ A1 [2]

94. 9702_s15_qp_23 Q: 2

- (a) constant rate of increase in velocity/acceleration from $t = 0$ to $t = 8$ s B1
- constant deceleration from $t = 8$ s to $t = 16$ s or constant rate of increase in velocity in the opposite direction from $t = 10$ s to $t = 16$ s B1 [2]
- (b) (i) area under lines to 10 s C1
- (displacement $\Rightarrow$) $(5.0 \times 8.0) / 2 + (5.0 \times 2.0) / 2 = 25$ m
or $\frac{1}{2} (10.0 \times 5.0) = 25$ m A1 [2]
- (ii) $a = (v - u) / t$ or gradient of line C1
- $= (-15.0 - 5.0) / 8.0$
- $= (-) 2.5 \text{ ms}^{-2}$ A1 [2]
- (iii) $\text{KE} = \frac{1}{2}mv^2$ C1
- $= 0.5 \times 0.4 \times (15.0)^2 = 45$ J A1 [2]
- (c) (distance $\Rightarrow$) 25 (m) ($= ut + \frac{1}{2}at^2$) $= 0 + \frac{1}{2} \times 2.5 \times t^2$ C1
- ($t = 4.5$ (4.47) s therefore) time to return $= 14.5$ s A1 [2]

95. 9702_w15_qp_21 Q: 3

- (a) work done is force $\times$ distance moved in direction of force
or
no work done along PQ as no displacement/distance moved in direction of force B1
- work done is same in vertical direction as same distance moved in direction of force B1 [2]
- (b) (i) at maximum height $t = 1.5$ (s) or $s = \frac{1}{2}(u + v)t$, $s = 11$ m and $t = 1.5$ s C1
- $V_v = 0 + 9.81 \times 1.5$ $V_v = (11 \times 2) / 1.5$
- $= 15$ (14.7) ms^{-1} A1 [2]
- (ii) straight line from (0,0) to (3.00, 25.5) B1 [1]
- (iii) at maximum height $V_h = 25.5/3$ ($= 8.5 \text{ ms}^{-1}$) B1
- ratio $= mgh / \frac{1}{2}mv^2$ C1
- $= (2 \times 9.81 \times 11.0) / (8.5)^2$
- $= 3.0$ (2.99) A1 [3]
- (iv) deceleration is greater/resultant force (weight and friction force) is greater M1
- time is less A1 [2]

96. 9702_w15_qp_22 Q: 2

- (a) (i) $v = u + at$ C1
 $0 = 3.6 - 3.0t$
 $t (= 3.6/3.0) = 1.2 \text{ s}$ A1 [2]
- (ii) (distance to rest from P = $(3.6 \times 1.2)/2 = 2.2$ (2.16)m A1 [1]
or
 $[0 - (3.6)^2]/[2 \times (-3.0)] = 2.2$ (2.16)m
or
 $3.6 \times 1.2 - \frac{1}{2} \times 3.0 \times (1.2)^2 = 2.2$ (2.16)m
or
 $0 + \frac{1}{2} \times 3.0 \times (1.2)^2 = 2.2$ (2.16)m
- (b) distance = $6.0 - 2.16 (= 3.84)$ C1
 $v^2 = u^2 + 2as = 2 \times 3.0 \times 3.84 (= 23.04)$ M1
or
 $x + 2 \times 2.16 = 6.0$ gives $x = 1.68$ (m) (C1)
 $v^2 = 3.6^2 + 2 \times 1.68 \times 3.0 (= 23.04)$ (M1)
or correct method with intermediate time calculated ($t = 1.6 \text{ s}$ from Q to R)
 $v = 4.8 \text{ m s}^{-1}$ A0 [2]
- (c) straight line from $v = 3.6 \text{ m s}^{-1}$ to $v = 0$ at $t = 1.2 \text{ s}$ B1
straight line continues with the same gradient as v changes sign B1
straight line from $v = 0$ intercept to $v = -4.8 \text{ m s}^{-1}$ B1 [3]
- (d) difference in KE = $\frac{1}{2}m(v^2 - u^2)$
 $= 0.5 \times 0.45 (4.8^2 - 3.6^2) [= 5.184 - 2.916]$ C1
 $= 2.3$ (2.27)J A1 [2]
-

97. 9702_w15_qp_23 Q: 3

- (a) (i) 1. $s = ut + \frac{1}{2}at^2$
 $192 = \frac{1}{2} \times 9.81 \times t^2$ C1
 $t = 6.3$ (6.26)s A1 [2]
2. $\max E_k (= mgh) = 0.27 \times 9.81 \times 192$ C1
- or
 calculation of v ($= 61.4$) and use of $E_k (= \frac{1}{2}mv^2) = \frac{1}{2} \times 0.27 \times (61.4)^2$ (C1)
 $\max E_k = 510$ (509)J A1 [2]
- (ii) velocity is proportional to time **or** velocity increases at a constant rate
 as acceleration is constant or resultant force is constant B1 [1]
- (iii) use of $v = at$ or $v^2 = 2as$ or $E = \frac{1}{2}mv^2$ to give $v = 61(.4)\text{ms}^{-1}$ B1 [1]
- (b) (i) R increases with velocity B1
 resultant force is $mg - R$ **or** resultant force decreases B1
 acceleration decreases B1 [3]
- (ii) at $v = 40\text{ms}^{-1}$, $R = 0.6(\text{N})$ C1
 $0.27 \times 9.8 - 0.6 = 0.27 \times a$
 $a = 7.6$ (7.58) ms^{-2} A1 [2]
- (iii) $R = \text{weight}$ for terminal velocity B1
either weight requires velocity to be about 80ms^{-1}
or at 60ms^{-1} , R is less than weight
 so does not reach terminal velocity B1 [2]

98. 9702_s20_qp_22 Q: 1

	Answer	Mark
(a)	(velocity =) change in displacement / time (taken)	B1
(b)	units of F : kg m s^{-2}	C1
	units of k : $\text{kg m s}^{-2} / [\text{m}^2 \times (\text{m s}^{-1})^2]$ $= \text{kg m}^{-3}$	A1
(c)	$P = Fv$	C1
	$4.8 \times 10^4 = 0.24 \times 5.1 \times v^3$	C1
	$v = 34\text{ms}^{-1}$	A1

99. 9702_s19_qp_23 Q: 3

	Answer	Mark
(a)	$P = Fv$	C1
	$P = 8.9 \cos 30^\circ \times 0.60$	A1
	$= 4.6 \text{ W}$	
(b)	$p = F/A$	C1
	$F = 8.9 \sin 30^\circ + (0.24 \times 9.81)$	C1
	$(= 6.80 \text{ N})$	
(c)(i)	$A = 6.80 / 3500$	A1
	$= 1.9 \times 10^{-3} \text{ m}^2$	
(c)(ii)	upwards/up	B1
(c)(iii)	the Earth/planet	B1

100. 9702_w19_qp_23 Q: 2

	Answer	Mark
(a)	(work done =) force $\times$ distance <u>moved</u> in direction of force	B1
(b)(i)	1. acceleration = gradient or $a = (v - u) / t$ or $a = \Delta v / t$	C1
	e.g. $a = 2.4 / 3.0$	A1
	$= 0.80 \text{ m s}^{-2}$	
	2. tension in cable = $(13.0 + 2.0) \times 10^3$	C1
(b)(ii)	work done = $15 \times 10^3 \times (3.0 \times 2.4)$	A1
	$= 1.1 \times 10^5 \text{ J}$	
(b)(iii)	power = Fv	C1
	$v = 2.0 \text{ (m s}^{-1}\text{)}$	C1
	input power = $(1.6 \times 10^4 \times 2.0) / 0.67$	A1
(b)(iv)	$= 4.8 \times 10^4 \text{ W}$	
(b)(v)	work is done against friction so (increase in) GPE is less (than work done by motor)	A1
	or energy is lost or transferred or converted to heat/thermal energy due to friction or resistance force	
	or work is done lifting the cable so GPE is less	

101. 9702_w18_qp_21 Q: 3

	Answer	Mark
(a)(i)	work (done)/time (taken)	B1
(a)(ii)	energy of a mass due to its position in a gravitational field	B1
(b)(i)	$P = Fv$	C1
	$= 2.0 \times 10^3 \times 45$	A1
	$= 9.0 \times 10^4 \text{ W}$	
(b)(ii)	1. $W = (2.0 \times 10^3) \times (45 \times 3.0 \times 60)$ or $W = 9.0 \times 10^4 \times 3.0 \times 60$	C1
	$W = 1.6 \times 10^7 \text{ J}$	A1
	2. $(\Delta)E_p = mg(\Delta)h$	C1
	$= 1200 \times 9.81 \times 3.3 \times 3.0 \times 60$	A1
	$= 7.0 \times 10^6 \text{ J}$	
(b)(iii)	3. $W = 1.6 \times 10^7 - 7.0 \times 10^6$	A1
	$= 9.0 \times 10^6 \text{ J}$	
(b)(iv)	force $= (9.0 \times 10^6) / (45 \times 3.0 \times 60)$	A1
	$= 1.1 \times 10^3 \text{ N}$	
(b)(iv)	constant velocity so no resultant force	B1
	no resultant force so in equilibrium	B1

102. 9702_m17_qp_22 Q: 3

	Answer	Mark
(a)	change of displacement/time (taken)	B1
(b)(i)	constant velocity, so resultant force is zero	M1
	(so car is) in (dynamic) equilibrium	A1
(b)(ii)	$F_D = 0.40 \text{ (kN)}$ or $0.40 \times 10^3 \text{ (N)}$	C1
	component of weight $= 2.0 \times 10^3 - 0.40 \times 10^3$ $= 1.6 \times 10^3 \text{ N}$	A1
(b)(iii)	$P = Fv$	C1
	$= 2.0 \times 10^3 \times 9.0 = 1.8 \times 10^4 \text{ W}$	A1
(b)(iv)	(driving) force $= 1.8 \times 10^4 / 15 (= 1.2 \times 10^3)$	C1
	$F_D = 0.66 \text{ (kN)}$ or $0.66 \times 10^3 \text{ (N)}$	C1
	acceleration $= (1.2 \times 10^3 - 0.66 \times 10^3) / 850$ $= 0.64 \text{ (0.635) m s}^{-2}$	A1

103. 9702_s15_qp_23 Q: 3

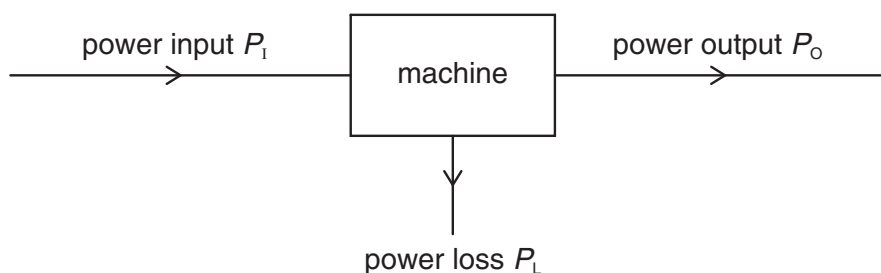
- (a) (power =) work done / time (taken) or rate of work done A1 [1]
- (b) (i) $F - R = ma$ C1
- $F = 1500 \times 0.82 + 1200$ C1
- $= 2400$ (2430) N A1 [3]
- (ii) $P = Fv$ C1
- $= (2430 \times 22) = 53\,000$ (53 500) W A1 [2]
- (c) (there is maximum power from car and) resistive force = force produced by car hence no acceleration
or
suggestion in terms of power produced by car and power wasted to overcome resistive force B1 [1]

104. 9702_m20_qp_22 Q: 3

	Answer	Mark
(a)	force $\times$ displacement in the direction of the force	B1
(b)(i)	displacement $= 4.4 \times 30$	C1
	work done $= 140 \cos 30^\circ \times 4.4 \times 30$	C1
	$= 1.6 \times 10^4$ J	A1
(b)(ii)	$p = F / A$	C1
	$F = 860 - 140 \sin 30^\circ (= 790)$	C1
	$A = 790 / 2400$ $= 0.33$ m ²	A1
(b)(iii)	$\sigma = F / A$ or $F / \pi r^2$ or $4F / \pi d^2$	C1
	$9.6 \times 10^6 = 4 \times 140 / \pi d^2$	A1
	$d = 4.3 \times 10^{-3}$ m	

	Answer	Mark
(c)	$E = \frac{1}{2}Fx$ or $\frac{1}{2}kx^2$ or area under graph	C1
	$(\Delta)E = \frac{1}{2} \times (140 + 210) \times 0.20 \times 10^{-3}$ or $(\Delta)E = (\frac{1}{2} \times 210 \times 0.60 \times 10^{-3}) - (\frac{1}{2} \times 140 \times 0.40 \times 10^{-3})$ or $(\Delta)E = (140 \times 0.20 \times 10^{-3}) + (\frac{1}{2} \times 0.20 \times 10^{-3} \times 70)$ or $(\Delta)E = [\frac{1}{2} \times 3.5 \times 10^5 \times (0.60 \times 10^{-3})^2] - [\frac{1}{2} \times 3.5 \times 10^5 \times (0.40 \times 10^{-3})^2]$	C1
	$\Delta E = 0.035$ J	A1

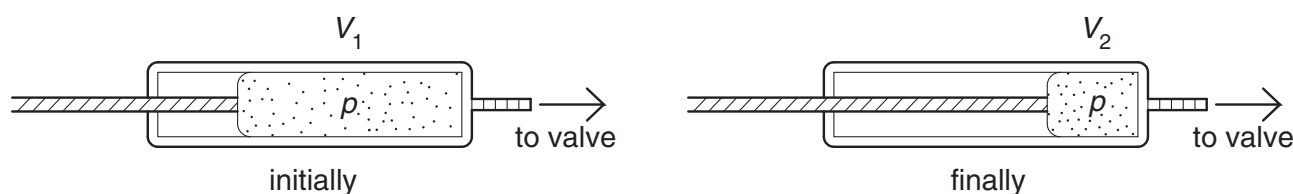
- 16 Power is transferred through a machine as shown.



What is the efficiency of the machine?

- A $\frac{P_i}{P_o + P_L}$ B $\frac{P_L}{P_i}$ C $\frac{P_L}{P_o}$ D $\frac{P_o}{P_i}$
- 17 Air in a bicycle pump is forced through a valve at a constant pressure p . In one stroke of the pump the volume of air in the pump chamber is reduced from V_1 to V_2 .

9702/1/M/J/02



What is the work done on this air in one stroke of the pump?

- A $\frac{p(V_1 + V_2)}{2}$
 B $p(V_1 + V_2)$
 C $p(V_1 - V_2)$
 D pV_1
- 19 To travel at a constant speed, a car engine provides 24 kW of useful power. The driving force on the car is 600 N.
- At what speed does it travel?
- A 2.5 m s^{-1}
 B 4.0 m s^{-1}
 C 25 m s^{-1}
 D 40 m s^{-1}
- 18 An area of land is an average of 2.0 m below sea level. To prevent flooding, pumps are used to lift rainwater up to sea level.

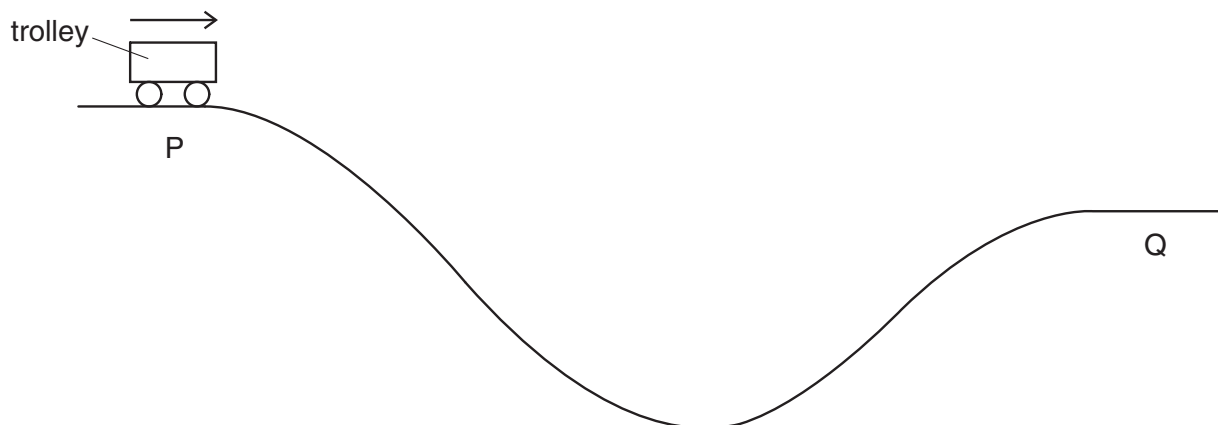
9702/1/M/J/02

9702/1/O/N/02

What is the minimum pump output power required to deal with $1.3 \times 10^9 \text{ kg}$ of rain per day?

- A 15 kW B 30 kW C 150 kW D 300 kW

- 18** A trolley runs from P to Q along a track. At Q its potential energy is 50 kJ less than at P. 9702/1/M/J/02



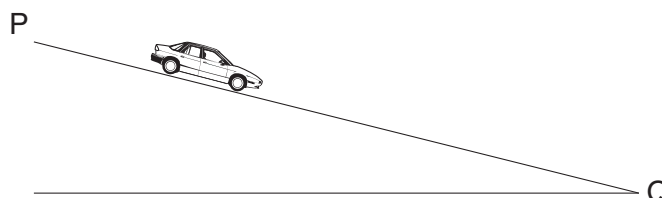
At P, the kinetic energy of the trolley is 5 kJ. Between P and Q the work the trolley does against friction is 10 kJ.

What is the kinetic energy of the trolley at Q?

- A** 35 kJ
 - B** 45 kJ
 - C** 55 kJ
 - D** 65 kJ
- 16** Which of the following is an expression for power? 9702/1/O/N/02

- A** energy x time
- B** force x displacement
- C** force x velocity
- D** mass x velocity

- 17** A car driver adjusts the pressure on a car's brakes so that the car travels at constant speed down a hill from P to Q. 9702/1/O/N/02



The magnitude of the change in the car's kinetic energy is ΔE_k . The magnitude of the change in its gravitational potential energy is ΔE_p .

Which statement is correct?

- A** $\Delta E_k > \Delta E_p$
- B** $\Delta E_k = \Delta E_p$
- C** $\Delta E_p > \Delta E_k > 0$
- D** $\Delta E_k = 0$

- 19 A twig from a tree drops from a 200 m high cliff on to a beach below. During its fall, 40% of the twig's energy is converted into thermal energy. 9702/1/O/N/02

What is the speed with which the twig hits the beach?

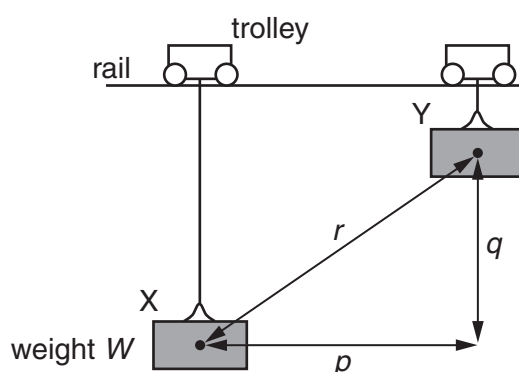
- A 35 m s^{-1} B 40 m s^{-1} C 49 m s^{-1} D 63 m s^{-1}

- 16 Which of the following expressions **defines** power?

9702/01/M/J/03

- A force x distance moved in the direction of the force
 B force x velocity
 C work done $\div$ time taken
 D work done x time taken

- 17 A weight W hangs from a trolley that runs along a rail. The trolley moves horizontally through a distance p and simultaneously raises the weight through a height q . 9702/01/M/J/03



As a result, the weight moves through a distance r from X to Y . It starts and finishes at rest.

How much work is done on the weight during this process?

- A Wp B $W(p + q)$ C Wq D Wr

- 15 A force F is applied to a freely moving object. At one instant of time, the object has velocity v and acceleration a . 9702/01/O/N/03

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

- 17 A mass is raised vertically. In time t , the increase in its gravitational potential energy is E_p and the increase in its kinetic energy is E_k . 9702/01/O/N/03

What is the average power input to the mass?

- A $(E_p - E_k)t$
 B $(E_p + E_k)t$
 C $\frac{E_p - E_k}{t}$
 D $\frac{E_p + E_k}{t}$

- 18 A boat moving at constant speed v through still water experiences a total frictional drag F . 9702/01/O/N/03

What is the power developed by the boat?

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

- 15 What is the expression used to **define** power? 9702/01/M/J/04

- | | |
|--|--|
| A $\frac{\text{energy output}}{\text{energy input}}$ | B energy x time taken |
| C force x velocity | D $\frac{\text{work done}}{\text{time taken}}$ |

- 16 A ball is thrown vertically upwards. 9702/01/M/J/04

Neglecting air resistance, which statement is correct?

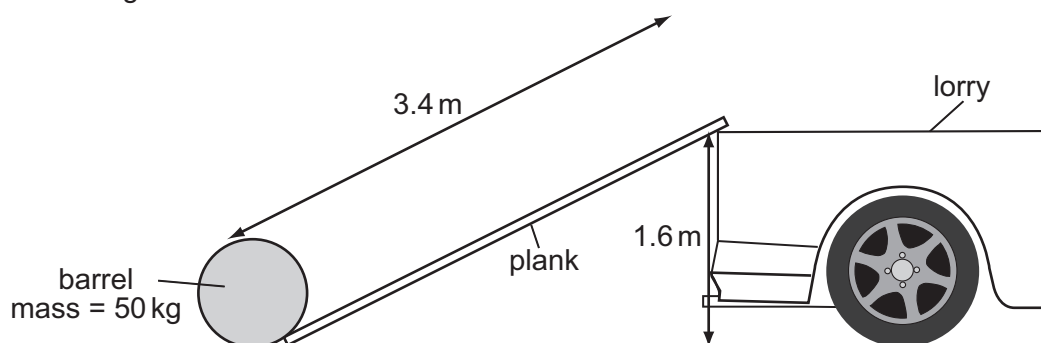
- A The kinetic energy of the ball is greatest at the greatest height attained.
 B By the principle of conservation of energy, the total energy of the ball is constant throughout its motion.
 C By the principle of conservation of momentum, the momentum of the ball is constant throughout its motion.
 D The potential energy of the ball increases uniformly with time during the ascent.

- 17 Car X is travelling at half the speed of car Y. Car X has twice the mass of car Y. 9702/01/M/J/04

Which statement is correct?

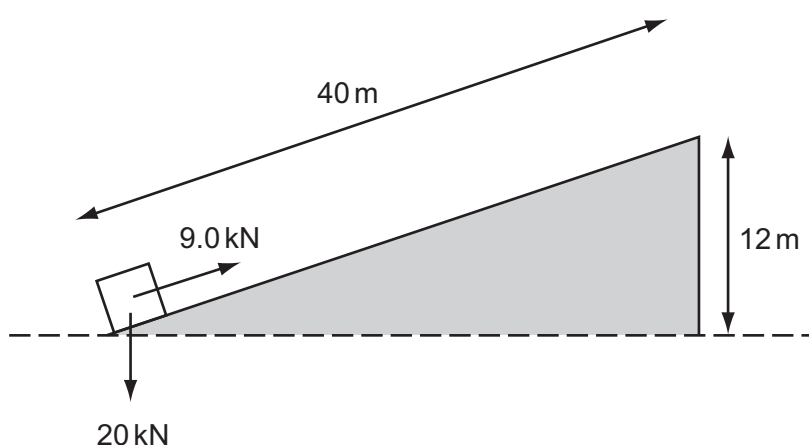
- A Car X has half the kinetic energy of car Y.
 B Car X has one quarter of the kinetic energy of car Y.
 C Car X has twice the kinetic energy of car Y.
 D The two cars have the same kinetic energy.

- 18** A barrel of mass 50 kg is loaded onto the back of a lorry 1.6 m high by pushing it up a smooth plank 3.4 m long. 9702/01/M/J/04



What is the minimum work done?

- A** 80 J **B** 170 J **C** 780 J **D** 1700 J
- 16** A horizontal force of 90 N is used to push a box across a horizontal floor. The frictional force on the box is 50 N. 9702/01/O/N/04
- What is the gain in kinetic energy of the box when it is moved through a distance of 6.0 m?
- A** 240 J **B** 300 J **C** 540 J **D** 840 J
- 17** A cyclist is capable of generating an average power of 3.0 kW during a 4.0 km speed trial. His aerodynamic suit and position on the cycle reduce resistive forces to 180 N. 9702/01/O/N/04
- What is the approximate time achieved in the speed trial?
- A** 140 s **B** 240 s **C** 1300 s **D** 2200 s
- 18** A constant force of 9.0 kN, parallel to an inclined plane, moves a body of weight 20 kN through a distance of 40 m along the plane at constant speed. The body gains 12 m in height, as shown. 9702/01/O/N/04



How much of the work done is dissipated as heat?

- A** 120 kJ **B** 240 kJ **C** 360 kJ **D** 600 kJ

- 15 The kinetic energy of a particle is increased by a factor of 4.

9702/01/O/N/04

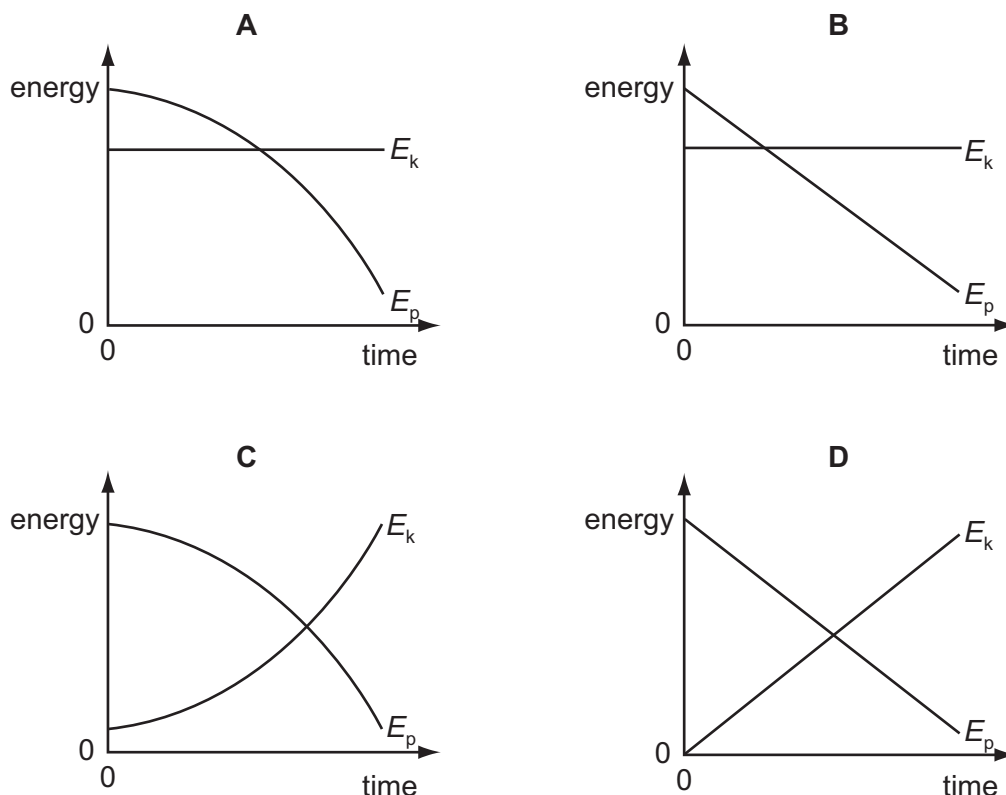
By what factor does its speed increase?

- A 2 B 4 C 8 D 16

- 15 A steel ball is falling at constant speed in oil.

Which graph shows the variation with time of the gravitational potential energy E_p and the kinetic energy E_k of the ball?

9702/01/M/J/05



- 17 A concrete cube of side 0.50 m and uniform density $2.0 \times 10^3 \text{ kg m}^{-3}$ is lifted 3.0 m vertically by a crane.

9702/01/M/J/05

What is the change in potential energy of the cube?

- A 0.75 kJ B 7.4 kJ C 29 kJ D 470 kJ

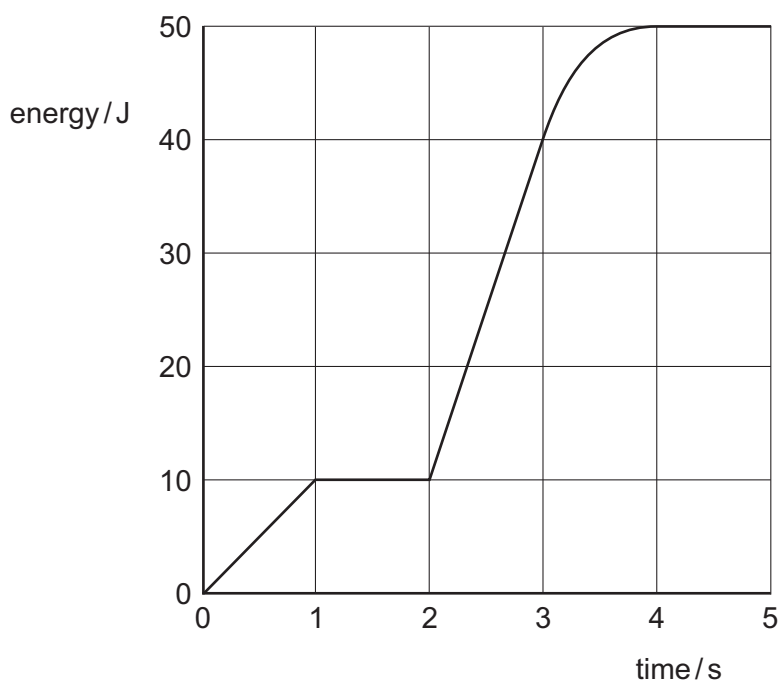
- 16 What is the internal energy of an object?

9702/01/M/J/06

- A It is the energy associated with the object's movement through space.
 B It is the energy associated with the random movement of the molecules in the object.
 C It is the energy due to the attractions between the molecules within the object.
 D It is the sum of all the microscopic potential and kinetic energies of the molecules.

- 16** An electrical generator is started at time zero. The total electrical energy generated during the first 5 seconds is shown in the graph.

9702/01/M/J/05



What is the maximum electrical power generated at any instant during these first 5 seconds?

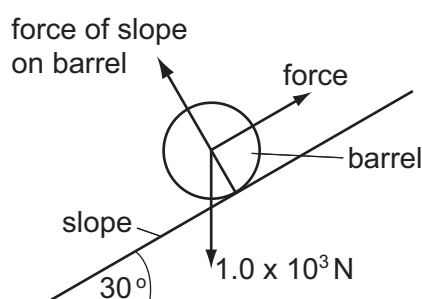
- 14** A car with a total mass of 1400 kg is travelling at 30 m s^{-1} .

9702/01/O/N/05

What is the kinetic energy of the car?

- 16** The diagram shows a barrel of weight $1.0 \times 10^3 \text{ N}$ on a frictionless slope inclined at 30° to the horizontal.

9702/01/O/N/05



A force is applied to the barrel to move it up the slope at constant speed. The force is parallel to the slope.

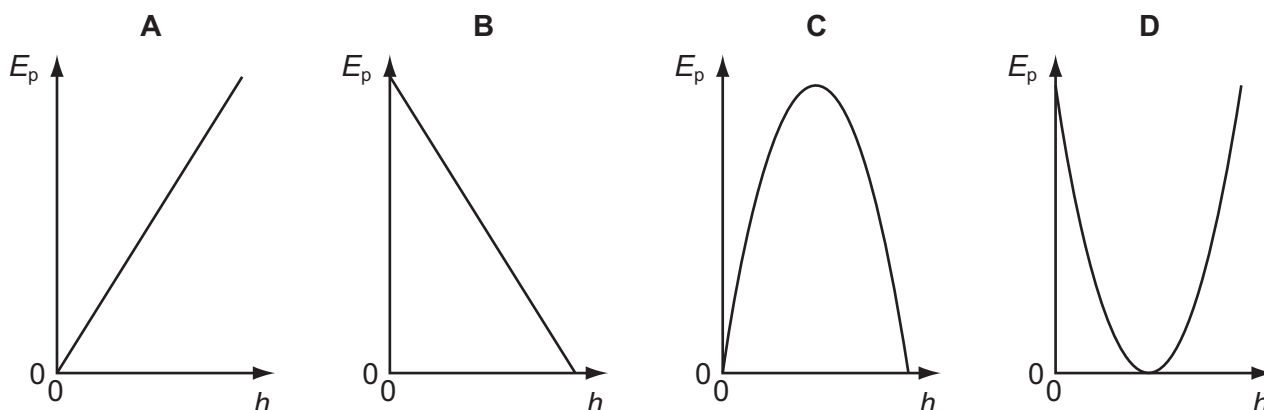
What is the work done in moving the barrel a distance of 5.0 m up the slope?

- A** $1.0 \times 10^4 \text{ J}$ **B** $2.5 \times 10^3 \text{ J}$ **C** $4.3 \times 10^3 \text{ J}$ **D** $5.0 \times 10^3 \text{ J}$

- 15 An object is thrown into the air.

Which graph shows how the potential energy E_p of the object varies with height h above the ground?

9702/01/O/N/05



- 17 A motorist travelling at 10 m s^{-1} can bring his car to rest in a braking distance of 10 m.

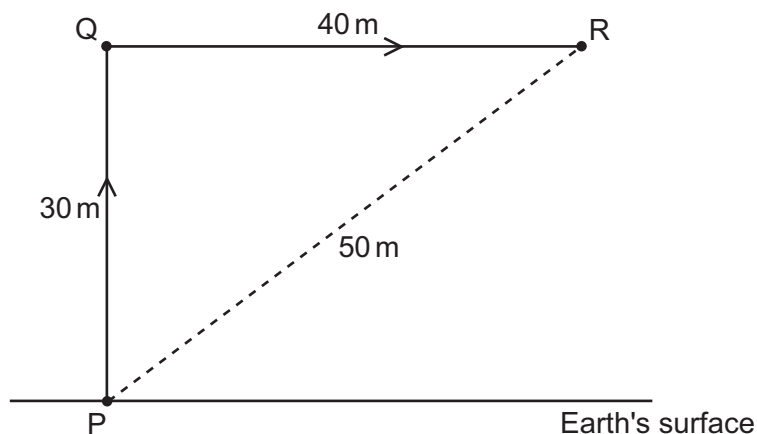
9702/01/M/J/06

In what distance could he bring the car to rest from a speed of 30 m s^{-1} using the same braking force?

- A 17 m B 30 m C 52 m D 90 m

- 18 A stone of weight 4.0 N in the Earth's gravitational field is moved from P to Q and then to R along the path shown.

9702/01/M/J/06



How much potential energy does the stone gain?

- A 120 J B 200 J C 280 J D 1200 J

- 17 In many old-style filament lamps, as much as 93 J of energy is emitted as thermal energy for every 7 J of energy emitted as light.

9702/01/O/N/06

What is the efficiency of the lamp, as the percentage of electrical energy converted to light energy?

- A 7 % B 8 % C 92 % D 93 %

- 18 An electric railway locomotive has a maximum mechanical output power of 4.0 MW. Electrical power is delivered at 25 kV from overhead wires. The overall efficiency of the locomotive in converting electrical power to mechanical power is 80 %.

9702/01/O/N/06

What is the current from the overhead wires when the locomotive is operating at its maximum power?

- A 130 A B 160 A C 200 A D 250 A

- 12 The diagram shows the masses and velocities of two trolleys about to collide.

9702/01/M/J/07



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

- 14 Which expression **defines** power?

9702/01/M/J/07

- A force $\times$ distance moved in the direction of the force
 B force $\times$ velocity
 C work done $\div$ time taken
 D work done $\times$ time taken

- 15 A car of mass 1000 kg first travels forwards at 25 ms⁻¹ and then backwards at 5 ms⁻¹.

9702/01/O/N/07

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

- A 200 kJ B 300 kJ C 325 kJ D 450 kJ

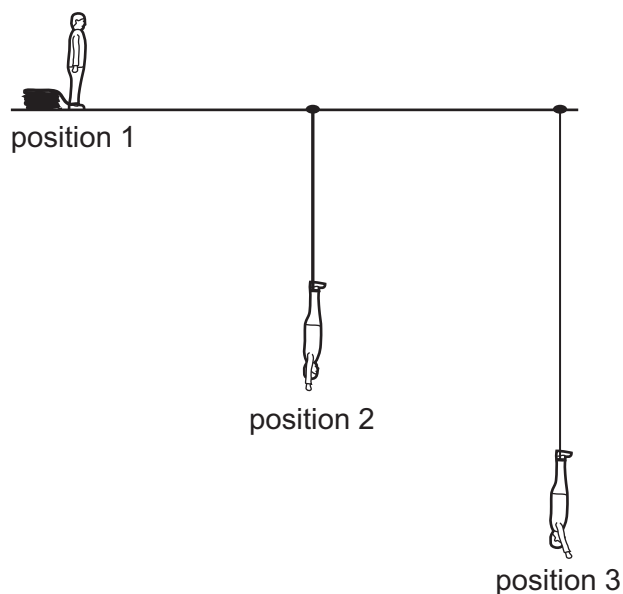
- 17 Which quantities are conserved in an inelastic collision?

9702/01/M/J/08

	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

- 16 When bungee jumping, a student starts with maximum gravitational potential energy (position 1), then falls freely until the rope fully unwinds (position 2), after which the rope starts to stretch until the lowest point of the jump is reached (position 3).

9702/01/O/N/07



What are the kinetic and elastic potential energies at position 3?

	kinetic energy	elastic potential energy
A	maximum	maximum
B	maximum	minimum
C	minimum	maximum
D	minimum	minimum

- 19 The total energy input E_{in} in a process is partly transferred to useful energy output U , and partly to energy that is wasted W .

9702/01/M/J/08

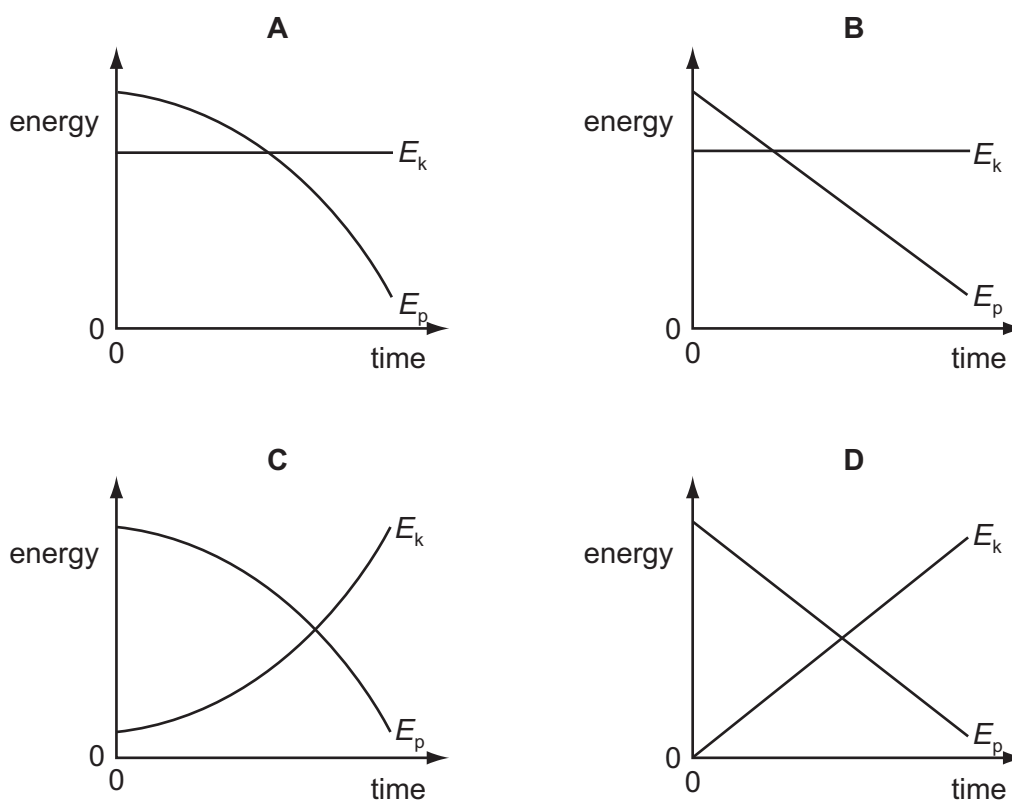
What is the efficiency of the process?

- A** $\frac{U}{W} \times 100\%$
- B** $\frac{W}{E_{\text{in}}} \times 100\%$
- C** $\frac{U}{E_{\text{in}}} \times 100\%$
- D** $\frac{U+W}{E_{\text{in}}} \times 100\%$

- 18 A steel ball is falling at constant speed in oil.

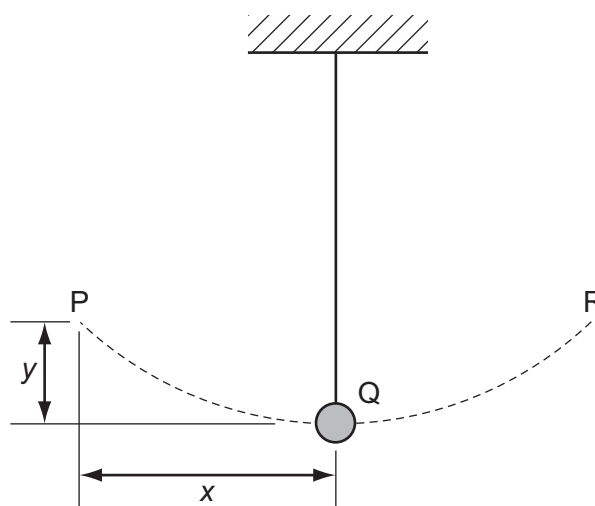
9702/01/M/J/08

Which graph shows the variation with time of the gravitational potential energy E_p and the kinetic energy E_k of the ball?



- 17 A pendulum bob oscillates between P and R.

9702/01/O/N/08



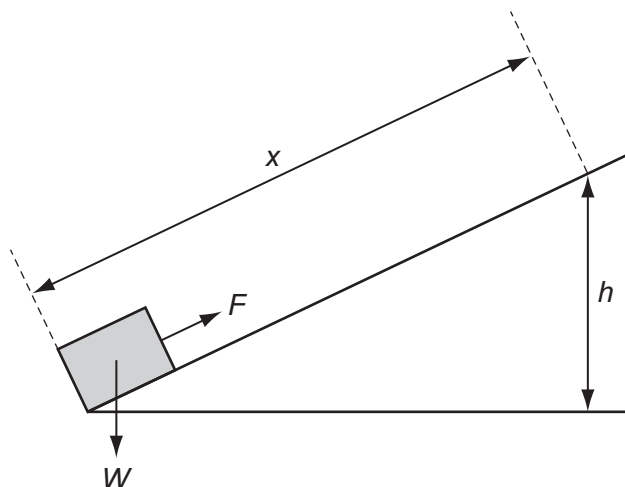
Assuming the gravitational potential energy lost in moving from P to Q is converted into kinetic energy, what is the speed of the bob at Q?

- A $\sqrt{2gx}$ B $2gx$ C $\sqrt{2gy}$ D $2gy$

- 15** A block of weight W is pulled up a rough slope by a force F .

9702/01/O/N/08

When the block has moved a distance x along the slope, it has risen height h .



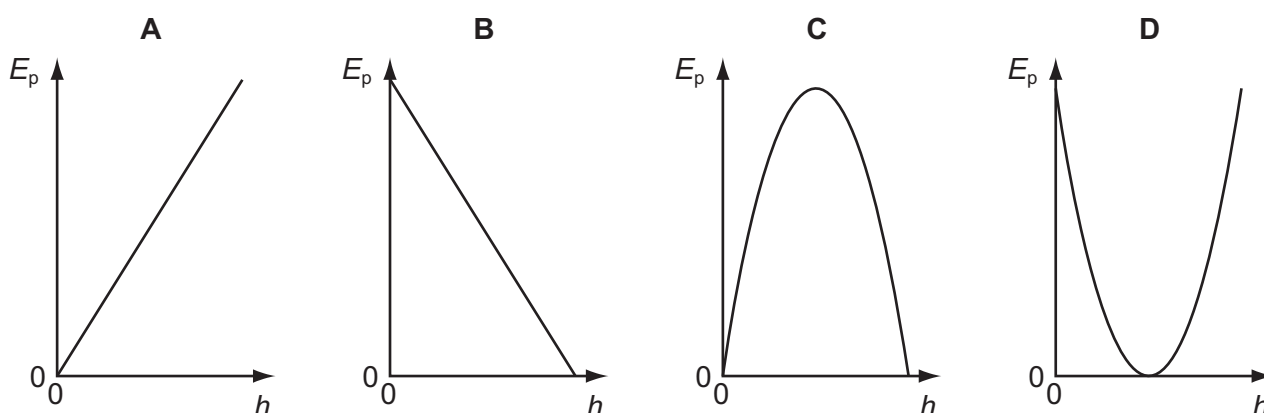
Which expressions give the amount of work done on the block and the amount of gravitational potential energy gained by the block?

	work done	gravitational potential energy
A	Fx	Wh
B	Fh	Wx
C	Wx	Fh
D	Wh	Fx

- 16** An object is thrown into the air.

9702/01/O/N/08

Which graph shows how the potential energy E_p of the object varies with height h above the ground?



18 Which operation involves the greatest mean power?

9702/01/O/N/08

- A a car moving against a resistive force of 0.4 kN at a constant speed of 20 m s^{-1}
- B a crane lifting a weight of 3 kN at a speed of 2 m s^{-1}
- C a crane lifting a weight of 5 kN at a speed of 1 m s^{-1}
- D a weight being pulled across a horizontal surface at a speed of 6 m s^{-1} against a frictional force of 1.5 kN

14 The forward motion of a motor-boat is opposed by forces F which vary with the boat's speed v in accordance with the relation $F = kv^2$, where k is a constant.

9702/01/M/J/09

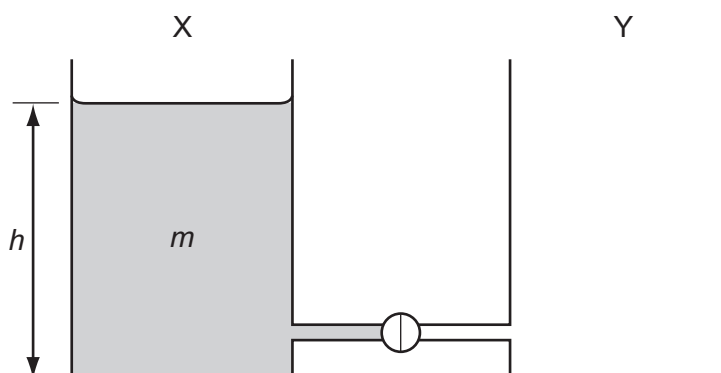
The effective power of the propellers required to maintain the speed v is P .

Which expression relates k , P and v ?

- A $k = \frac{P}{v}$ B $k = \frac{P}{v^2}$ C $k = \frac{P}{v^3}$ D $k = \frac{P}{v^4}$

15 The diagram shows two identical vessels X and Y connected by a short pipe with a tap.

9702/01/M/J/09



Initially, X is filled with water of mass m to a depth h , and Y is empty.

When the tap is opened, water flows from X to Y until the depths of water in both vessels are equal.

How much potential energy is lost by the water during this process? (g = acceleration of free fall)

- A 0 B $\frac{mgh}{4}$ C $\frac{mgh}{2}$ D mgh

14 A projectile is launched at 45° to the horizontal with initial kinetic energy E .

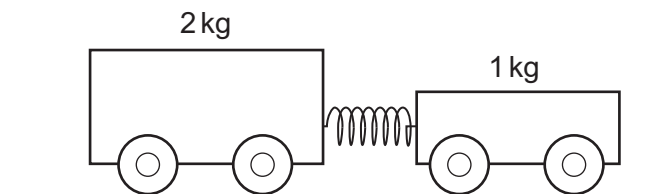
9702/11/O/N/09

Assuming air resistance to be negligible, what will be the kinetic energy of the projectile when it reaches its highest point?

- A $0.50E$ B $0.71E$ C $0.87E$ D E

- 15 Two trolleys are placed together on a horizontal runway with a compressed spring between them.

9702/11/O/N/09



When they are released, the 2 kg trolley moves to the left at 2 m s^{-1} .

How much energy was stored in the spring?

- A 4 J B 6 J C 8 J D 12 J

- 16 An electric railway locomotive has a maximum mechanical output power of 4.0 MW. Electrical power is delivered at 25 kV from overhead wires. The overall efficiency of the locomotive in converting electrical power to mechanical power is 80 %.

9702/11/O/N/09

What is the current from the overhead wires when the locomotive is operating at its maximum power?

- A 130 A B 160 A C 200 A D 250 A

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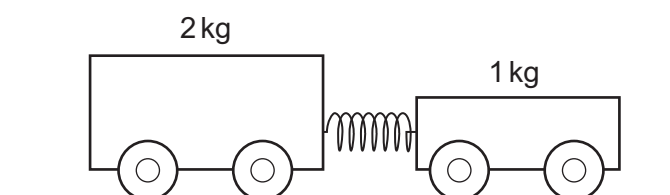
9702/12/O/N/09

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9702/12/O/N/09



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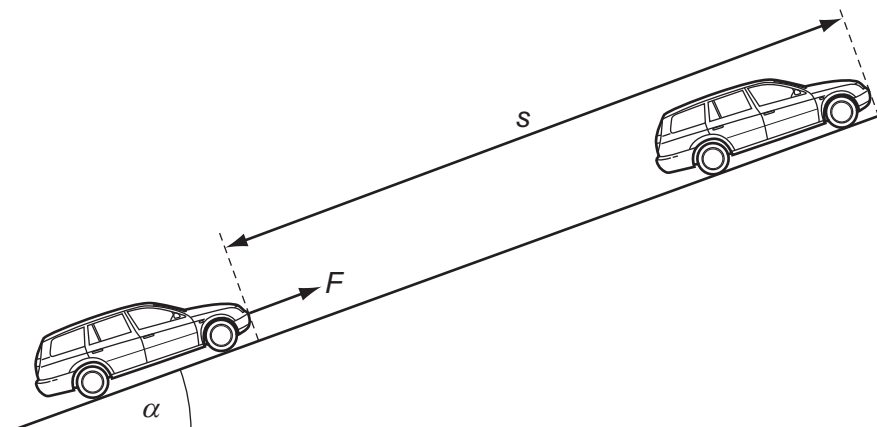
- A 130 A B 160 A C 200 A D 250 A

- 15 A force of 1000 N is needed to lift the hook of a crane at a steady velocity. The crane is then used to lift a load of mass 1000 kg at a velocity of 0.50 m s^{-1} . 9702/11/M/J/10

How much of the power developed by the motor of the crane is used in lifting the hook and the load? Assume that the acceleration of free fall g is equal to 10 m s^{-2} .

- A 5.0 kW B 5.5 kW C 20 kW D 22 kW

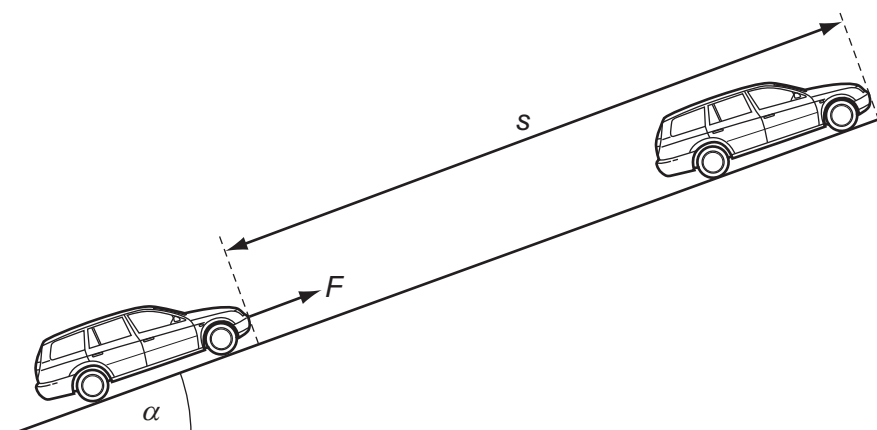
- 16 A constant force F , acting on a car of mass m , moves the car up the slope through a distance s at constant velocity v . The angle of the slope to the horizontal is α . 9702/11/M/J/10



Which expression gives the efficiency of the process?

- A $\frac{mgs \sin \alpha}{Fv}$ B $\frac{mv}{Fs}$ C $\frac{mv^2}{2Fs}$ D $\frac{mg \sin \alpha}{F}$

- 15 A constant force F , acting on a car of mass m , moves the car up the slope through a distance s at constant velocity v . The angle of the slope to the horizontal is α . 9702/12/M/J/10



Which expression gives the efficiency of the process?

- A $\frac{mgs \sin \alpha}{Fv}$ B $\frac{mv}{Fs}$ C $\frac{mv^2}{2Fs}$ D $\frac{mg \sin \alpha}{F}$

- 16** A force of 1000 N is needed to lift the hook of a crane at a steady velocity. The crane is then used to lift a load of mass 1000 kg at a velocity of 0.50 m s^{-1} . 9702/12/M/J/10

How much of the power developed by the motor of the crane is used in lifting the hook and the load? Assume that the acceleration of free fall g is equal to 10 m s^{-2} .

- A** 5.0 kW **B** 5.5 kW **C** 20 kW **D** 22 kW

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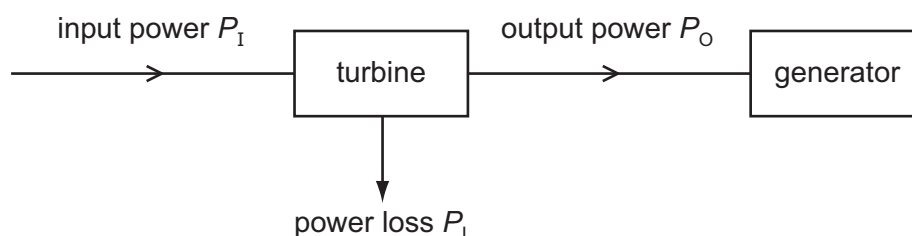
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- A** 5.0 kW **B** 5.5 kW **C** 20 kW **D** 22 kW

- 16** What is the internal energy of a system? 9702/11/O/N/10

- A** the amount of heat supplied to the system
B the energy of the atoms of the system
C the total kinetic energy of the system
D the total potential energy of the system

- 17** A steam turbine is used to drive a generator. The input power to the turbine is P_I and the output power P_O . The power loss in the turbine is P_L , as shown below. 9702/11/O/N/10



What is the efficiency of the turbine?

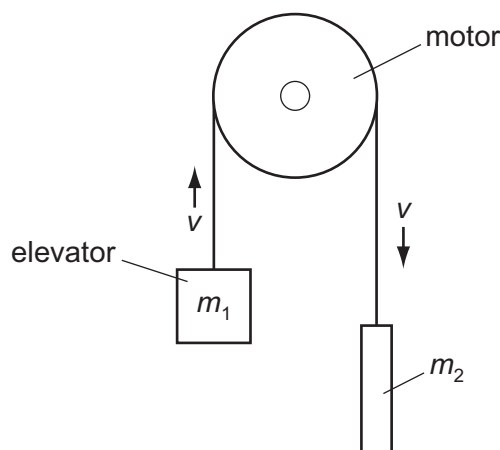
- A** $\frac{P_L}{P_O}$ **B** $\frac{P_I}{P_O}$ **C** $\frac{P_L}{P_I}$ **D** $\frac{P_O}{P_I}$

- 17** What are units of work, energy and power? 9702/12/O/N/10

	work	energy	power
A	J	Nm	J
B	J s^{-1}	J	J s^{-1}
C	Nm	Nm	W
D	Nm	W	W

- 18 The diagram shows a lift system in which the elevator (mass m_1) is partly counterbalanced by a heavy weight (mass m_2).

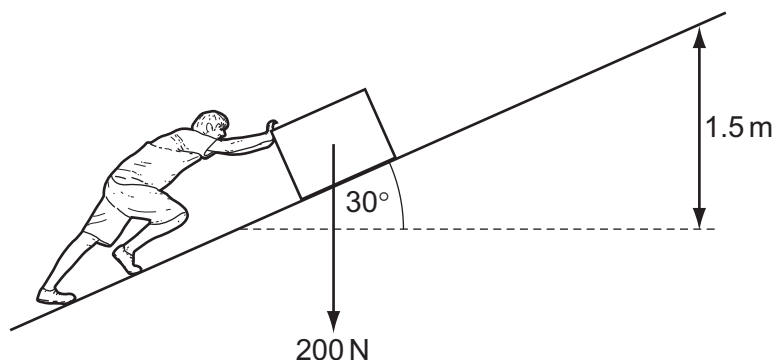
9702/11/O/N/10



At what rate does the motor provide energy to the system when the elevator is rising at a steady speed v ? (g = acceleration of free fall)

- A $\frac{1}{2} m_1 v^2$
 B $\frac{1}{2} (m_1 - m_2) v^2$
 C $m_1 g v$
 D $(m_1 - m_2) g v$
- 14 A box of weight 200 N is pushed so that it moves at a steady speed along a ramp, through a height of 1.5 m. The ramp makes an angle of 30° with the ground. The frictional force on the box is 150 N while the box is moving.

9702/12/O/N/10



What is the work done by the person?

- A 150 J B 300 J C 450 J D 750 J
- 16 The kinetic energy of a vehicle of mass 1000 kg is 4.5×10^5 J. It is stopped by applying a constant braking force of 6000 N.

9702/12/O/N/10

What is its stopping distance?

- A 37 m B 75 m C 150 m D 300 m

- 15 A raindrop of mass m is falling vertically through the air with a steady speed v . The raindrop experiences a retarding force kv due to the air, where k is a constant. The acceleration of free fall is g .

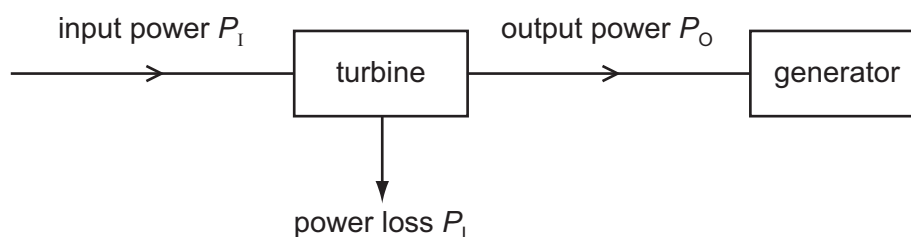
9702/12/O/N/10

Which expression gives the kinetic energy of the raindrop?

- A $\frac{mg}{k}$ B $\frac{mg^2}{2k^2}$ C $\frac{m^3g^2}{k^2}$ D $\frac{m^3g^2}{2k^2}$

- 16 A steam turbine is used to drive a generator. The input power to the turbine is P_I and the output power P_O . The power loss in the turbine is P_L , as shown below.

9702/13/O/N/10



What is the efficiency of the turbine?

- A $\frac{P_L}{P_O}$ B $\frac{P_I}{P_O}$ C $\frac{P_L}{P_I}$ D $\frac{P_O}{P_I}$

- 18 What is the internal energy of a system?

9702/13/O/N/10

- A the amount of heat supplied to the system
B the energy of the atoms of the system
C the total kinetic energy of the system
D the total potential energy of the system

- 18 An electric motor produces 120 W of useful mechanical output power. The efficiency of the motor is 60 %.

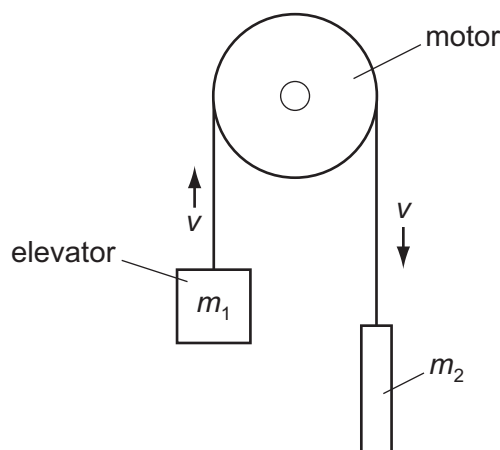
9702/12/M/J/11

Which row is correct?

	electrical power input/W	waste heat power output/W
A	72	48
B	192	72
C	200	72
D	200	80

- 17 The diagram shows a lift system in which the elevator (mass m_1) is partly counterbalanced by a heavy weight (mass m_2).

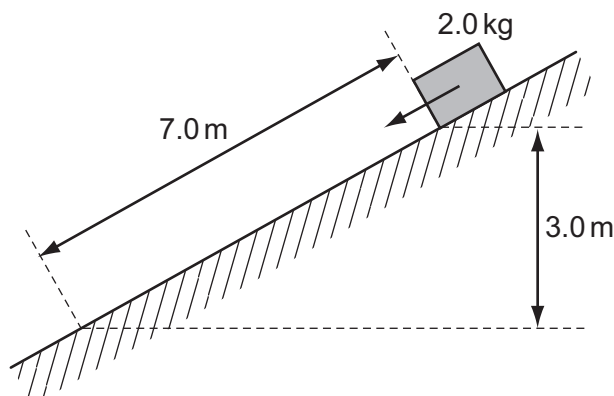
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At what rate does the motor provide energy to the system when the elevator is rising at a steady speed v ? (g = acceleration of free fall)

- A $\frac{1}{2} m_1 v^2$
 B $\frac{1}{2} (m_1 - m_2) v^2$
 C $m_1 g v$
 D $(m_1 - m_2) g v$
- 15 A block of mass 2.0 kg is released from rest on a slope. It travels 7.0 m down the slope and falls a vertical distance of 3.0 m. The block experiences a frictional force parallel to the slope of 5.0 N.

9702/11/M/J/11



What is the speed of the block after falling this distance?

- A 4.9 ms^{-1} B 6.6 ms^{-1} C 8.6 ms^{-1} D 10.1 ms^{-1}
- 16 A man has a mass of 80 kg. He ties himself to one end of a rope which passes over a single fixed pulley. He pulls on the other end of the rope to lift himself up at an average speed of 50 cm s^{-1} .

9702/11/M/J/11

What is the average useful power at which he is working?

- A 40 W B 0.39 kW C 4.0 kW D 39 kW

- 17 A body travelling with a speed of 10 m s^{-1} has kinetic energy 1500 J. 9702/11/M/J/11

If the speed of the body is increased to 40 m s^{-1} , what is its new kinetic energy?

- A 4500 J B 6000 J C 24 000 J D 1 350 000 J

- 19 A hammer with 10 J of kinetic energy hits a nail and pushes it 5.0 mm into a plank. 9702/12/M/J/11

Both the hammer and nail come to rest after the collision.

What is the average force that acts on the nail while it moves the 5.0 mm?

- A 0.050 N B 2.0 N C 50 N D 2000 N

- 14 A steel sphere is dropped vertically onto a horizontal metal plate. The sphere hits the plate with a speed u , leaves it at a speed v , and rebounds vertically to half of its original height. 9702/13/M/J/11

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

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

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If the speed of the body is increased to 40 m s^{-1} , what is its new kinetic energy?

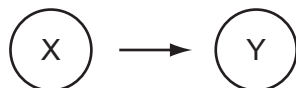
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- 16 The diagram shows a particle X, with kinetic energy E_k , about to collide with a stationary particle Y. Both particles have the same mass. 9702/11/O/N/11



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 $\frac{3E_k}{4}$

- 17 The first column in the table gives four examples of work being done. The second column gives more detail of the action.

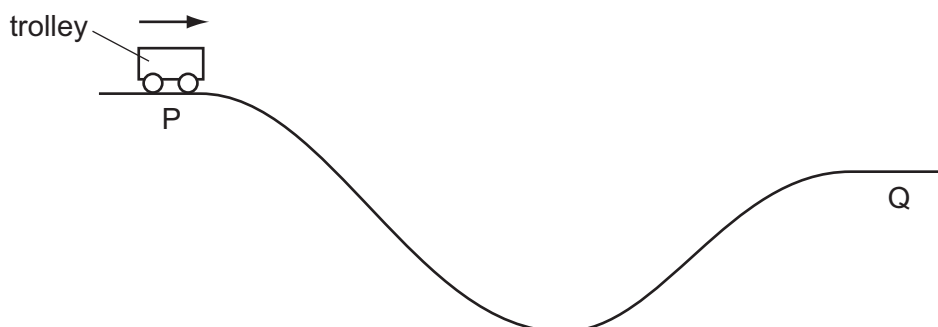
9702/11/O/N/11

Which row is **not** correct?

	example	detail
A	a girl dives from a diving board into a swimming pool	work is done by the girl against gravity as she falls
B	a man pushes a car along a level road	work is done by the man against friction
C	an electron is accelerated towards a positively-charged plate	work is done on the electron by the electric field of the plate
D	a piston is pushed outwards as a gas expands	work is done on the atmosphere by the gas

- 18 A trolley runs from P to Q along a track. At Q its potential energy is 50 kJ less than at P.

9702/11/O/N/11



At P, the kinetic energy of the trolley is 5 kJ. Between P and Q, the work the trolley does against friction is 10 kJ.

What is the kinetic energy of the trolley at Q?

- A** 35 kJ **B** 45 kJ **C** 55 kJ **D** 65 kJ

- 16 The kinetic energy of a vehicle of mass 1000 kg is 4.5×10^5 J. It is braked with a total constant braking force of 6000 N.

9702/12/O/N/11

What will be its stopping distance?

- A** 37 m **B** 75 m **C** 150 m **D** 300 m

- 18 What is the unit of power in SI base units?

9702/12/O/N/11

- A** kg m s^{-2} **B** kg m s^{-3} **C** $\text{kg m}^2 \text{s}^{-2}$ **D** $\text{kg m}^2 \text{s}^{-3}$

- 19** An electric motor is required to produce 120 W of mechanical output power. The efficiency of the motor is 80 %.

9702/11/O/N/11

Which row is correct?

	electrical power input to motor / W	waste heat output from motor / W
A	120	24
B	120	96
C	150	30
D	150	120

- 15** When a horizontal force F is applied to a frictionless trolley over a distance s , the kinetic energy of the trolley changes from 4 J to 8 J.

9702/12/O/N/11

If a force of $2F$ is applied to the trolley over a distance of $2s$, what will the original kinetic energy of 4 J become?

- A** 16 J **B** 20 J **C** 32 J **D** 64 J

- 17** In many old-style filament lamps, as much as 92 J of energy is emitted as thermal energy for every 8 J of energy emitted as light.

9702/12/O/N/11

What is the efficiency of the lamp, as the percentage of electrical energy converted to light energy?

- A** 8 % **B** 9 % **C** 91 % **D** 92 %

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9702/13/O/N/11

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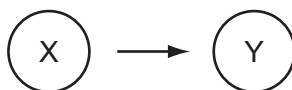
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- 16 A concrete cube of side 0.60 m and uniform density $2.0 \times 10^3 \text{ kg m}^{-3}$ is lifted 5.0 m vertically by a crane. 9702/11/M/J/12

What is the change in potential energy of the cube?

- A** 2.2 kJ **B** 21 kJ **C** 59 kJ **D** 450 kJ

- 17 The force resisting the motion of a car is taken as being proportional to the square of the car's speed. The magnitude of the force at a speed of 20 m s^{-1} is 800 N. 9702/11/M/J/12

What effective power is required from the car's engine to maintain a steady speed of 40 m s^{-1} ?

- A** 32 kW **B** 64 kW **C** 128 kW **D** 512 kW

18 The data below are taken from a test of a petrol engine for a motor car.

9702/11/M/J/12

power output	150 kW
fuel consumption	20 litres per hour
energy content of fuel	40 MJ per litre

Which expression will evaluate the efficiency of the engine?

A $\frac{150 \times 10^3}{40 \times 10^6 \times 20 \times 60 \times 60}$

B $\frac{150 \times 10^3 \times 60 \times 60}{20 \times 40 \times 10^6}$

C $\frac{150 \times 10^3 \times 40 \times 10^6 \times 20}{60 \times 60}$

D $\frac{150 \times 10^3 \times 20}{40 \times 10^3 \times 60 \times 60}$

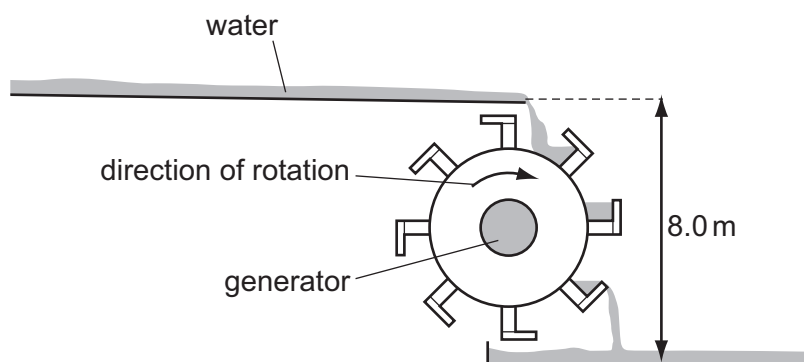
19 What is the internal energy of an object?

9702/11/M/J/12

- A It is the energy associated with the object's movement through space.
- B It is the energy associated with the random movement of the molecules in the object.
- C It is the energy due to the attractions between the molecules in the object.
- D It is the sum of all the microscopic potential and kinetic energies of the molecules in the object.

18 The diagram shows the design of a water wheel which drives a generator to produce electrical energy. The flow rate of the water is 200 kg s^{-1} . The generator supplies a current of 32 A at a voltage of 230 V.

9702/12/M/J/12



Ignoring any changes in kinetic energy of the water, what is the efficiency of the system?

- A 14 %
- B 16 %
- C 22 %
- D 47 %

- 19 A car engine exerts an average force of 500 N in moving the car 1.0 km in 200 s. 9702/12/M/J/12

What is the average power developed by the engine?

- A 2.5 W B 2.5 kW C 100 kW D 100 MW

- 20 A mass of gas enclosed in a cylinder by a piston is heated gently. At the same time, the piston is moved so that the pressure remains constant. 9702/12/M/J/12

As a result of this, what will **not** occur?

- A The average velocity of the molecules will increase.
 B The mean separation of the molecules will increase.
 C The molecules will travel greater distances between collisions.
 D The number of collisions per second of the molecules on the piston will increase.

- 17 Initially, four identical uniform blocks, each of mass m and thickness h , are spread on a table. 9702/12/M/J/12



How much work is done on the blocks in stacking them on top of one another?

- A $3mgh$ B $6mgh$ C $8mgh$ D $10mgh$

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B $\frac{150 \times 10^3 \times 60 \times 60}{20 \times 40 \times 10^6}$

C $\frac{150 \times 10^3 \times 40 \times 10^6 \times 20}{60 \times 60}$

D $\frac{150 \times 10^3 \times 20}{40 \times 10^3 \times 60 \times 60}$

- 19** A piston in a gas supply pump has an area of 500 cm^2 and it moves a distance of 30 cm during one stroke. 9702/12/O/N/12

The pump moves the gas against a fixed pressure of 4000 Pa.

How much work is done by the piston during one stroke?

- A** 60 J **B** $6.0 \times 10^3 \text{ J}$ **C** $6.0 \times 10^5 \text{ J}$ **D** $6.0 \times 10^7 \text{ J}$

- 20** A railway engine accelerates a train of total mass 1200 tonnes (1 tonne = 1000 kg) from rest to a speed of 75 m s^{-1} . 9702/12/O/N/12

How much useful work must be done on the train to reach this speed?

- A** $1.7 \times 10^6 \text{ J}$ **B** $3.4 \times 10^6 \text{ J}$ **C** $1.7 \times 10^9 \text{ J}$ **D** $3.4 \times 10^9 \text{ J}$

- 21** A crane is being used to lift containers off a ship. One container has a mass of 14 000 kg and is being lifted vertically with a speed of 3.2 m s^{-1} . 9702/12/O/N/12

The electric motor being used to supply the power to lift the container is using a current of 240 A at a potential difference of 2200 V.

What is the efficiency of the system?

- A** 8.1 % **B** 8.5 % **C** 48 % **D** 83 %

- 22** Trains supply coal to a power station. The table below gives quantities describing the operation of the power station.

9702/12/O/N/12

	symbol	unit
power station output	P	W
number of trains per day	N	
mass of coal on a train	M	kg
energy from 1 kg of coal	J	J
number of seconds in one day	S	

Which expression gives the efficiency of the power station?

- A** $\frac{PS}{NMJ}$ **B** $\frac{PSN}{MJ}$ **C** $\frac{NMJ}{PS}$ **D** $\frac{NM}{PSJ}$

- 18** The kinetic energy of a particle is increased by a factor of 4.

9702/11/O/N/12

By what factor does its speed increase?

- A** 2 **B** 4 **C** 8 **D** 16

- 19** A piston in a gas supply pump has an area of 600 cm^2 and it moves a distance of 40 cm during one stroke. The pump moves the gas against a fixed pressure of 5000 Pa.

9702/11/O/N/12

How much work is done by the piston during one stroke?

- A** $1.2 \times 10^2 \text{ J}$ **B** $1.2 \times 10^4 \text{ J}$ **C** $1.2 \times 10^6 \text{ J}$ **D** $1.2 \times 10^8 \text{ J}$

- 20** A railway engine accelerates a train of total mass 800 tonnes (1 tonne = 1000 kg) from rest to a speed of 50 m s^{-1} .

9702/11/O/N/12

How much work must be done on the train to reach this speed?

- A** $1.0 \times 10^6 \text{ J}$ **B** $2.0 \times 10^6 \text{ J}$ **C** $1.0 \times 10^9 \text{ J}$ **D** $2.0 \times 10^9 \text{ J}$

- 21** Water from a reservoir is fed to the turbine of a hydroelectric system at a rate of 500 kg s^{-1} . The reservoir is 300 m above the level of the turbine.

9702/11/O/N/12

The electrical output from the generator driven by the turbine is 200 A at a potential difference of 6000 V.

What is the efficiency of the system?

- A** 8.0% **B** 8.2% **C** 80% **D** 82%

- 19 A piston in a gas supply pump has an area of 400 cm^2 and it moves a distance of 25 cm during one stroke.

9702/13/O/N/12

The pump moves the gas against a fixed pressure of 3000 Pa.

How much work is done by the piston during one stroke?

- A 30 J B $3.0 \times 10^3 \text{ J}$ C $3.0 \times 10^5 \text{ J}$ D $3.0 \times 10^7 \text{ J}$

- 20 A transformer has the following input and output.

9702/13/O/N/12

	potential difference / V	current / A
input	11 000	28
output	240	1200

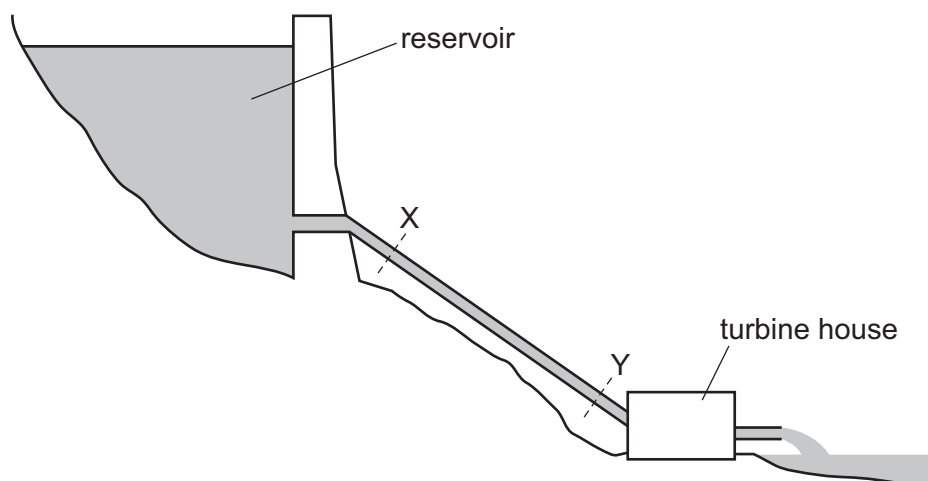
What is the efficiency of the transformer?

- A 0.94 % B 1.0 % C 11 % D 94 %

- 21 The diagram shows a hydroelectric power station.

9702/13/O/N/12

The reservoir is linked to the turbines by a pipe of uniform cross-sectional area. Water flows from the reservoir, through the pipe and through the turbines at a constant rate.

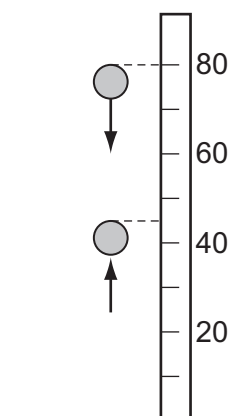


Which statement about the change of energy of the water as it moves from X to Y is correct?

- A It gains both gravitational potential energy and kinetic energy.
 B It loses gravitational potential energy and gains elastic potential energy.
 C It loses gravitational potential energy and gains kinetic energy.
 D It loses both elastic potential energy and gravitational potential energy.

- 17 A solid rubber ball has a diameter of 8.0 cm. It is released from rest with the top of the ball 80 cm above a horizontal surface. It falls vertically and then bounces back up so that the maximum height reached by the top of the ball is 45 cm, as shown.

9702/11/M/J/13

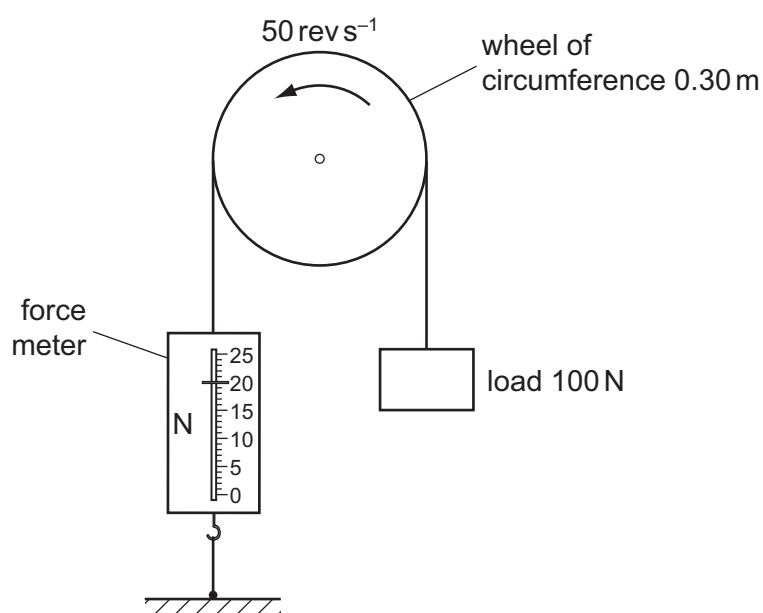


If the kinetic energy of the ball is 0.75 J just before it strikes the surface, what is its kinetic energy just after it leaves the surface?

- A 0.36 J B 0.39 J C 0.40 J D 0.42 J
- 19 The diagram shows a wheel of circumference 0.30 m. A rope is fastened at one end to a force meter. The rope passes over the wheel and supports a freely hanging load of 100 N. The wheel is driven by an electric motor at a constant rate of 50 revolutions per second.

9702/11/M/J/13

When the wheel is turning at this rate, the force meter reads 20 N.



What is the output power of the motor?

- A 0.3 kW B 1.2 kW C 1.8 kW D 3.8 kW

- 18 A wind turbine has blades that sweep an area of 2000 m^2 . It converts the power available in the wind to electrical power with an efficiency of 50%. 9702/11/M/J/13

What is the electrical power generated if the wind speed is 10 m s^{-1} ? (The density of air is 1.3 kg m^{-3} .)

- A 130 kW B 650 kW C 1300 kW D 2600 kW

- 15 A ball is thrown vertically upwards. 9702/12/M/J/13

Neglecting air resistance, which statement is correct?

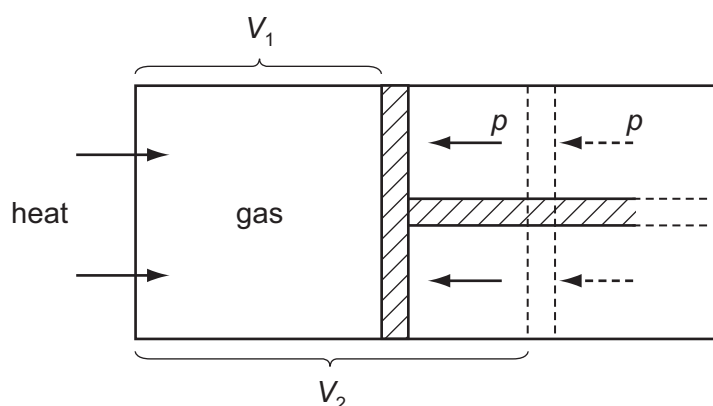
- A The kinetic energy of the ball is greatest at the greatest height attained.
 B By the principle of conservation of energy, the total energy of the ball is constant throughout its motion.
 C By the principle of conservation of momentum, the momentum of the ball is constant throughout its motion.
 D The potential energy of the ball increases uniformly with time during its ascent.

- 16 A bow of mass 400 g shoots an arrow of mass 120 g vertically upwards. The potential energy stored in the bow just before release is 80 J. The system has an efficiency of 28%. 9702/12/M/J/13

What is the height reached by the arrow when air resistance is neglected?

- A 4 m B 19 m C 187 m D 243 m

- 18 A gas is enclosed inside a cylinder which is fitted with a frictionless piston. 9702/12/M/J/13



Initially, the gas has a volume V_1 and is in equilibrium with an external pressure p . The gas is then heated slowly so that it expands, pushing the piston back until the volume of the gas has increased to V_2 .

How much work is done by the gas during this expansion?

- A $p(V_2 - V_1)$ B $\frac{1}{2}p(V_2 - V_1)$ C $p(V_2 + V_1)$ D $\frac{1}{2}p(V_2 + V_1)$

- 17 A train on a mountain railway is carrying 200 people of average mass 70 kg up a slope at an angle of 30° to the horizontal and at a speed of 6.0 m s^{-1} . The train itself has a mass of 80 000 kg. The percentage of the power from the engine which is used to raise the passengers and the train is 40 %.

9702/12/M/J/13

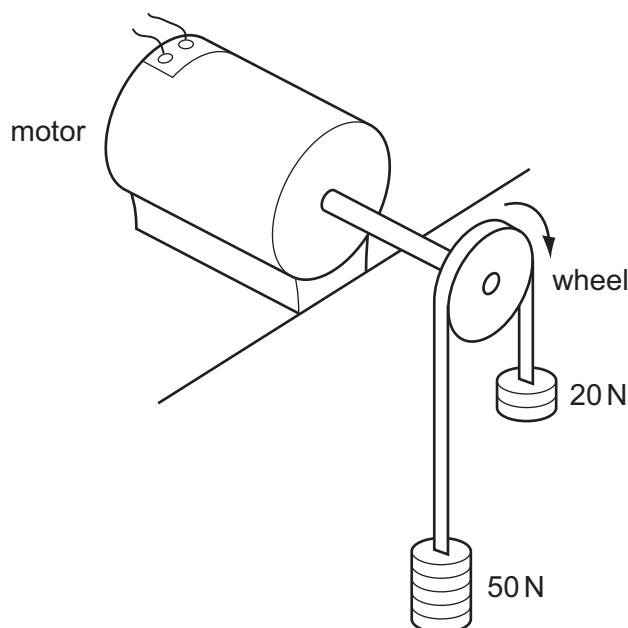
What is the power of the engine?

- A 1.1 MW B 2.8 MW C 6.9 MW D 14 MW

- 16 The diagram shows an arrangement used to find the output power of an electric motor.

9702/13/M/J/13

The wheel attached to the motor's axle has a circumference of 0.5 m and the belt which passes over it is stationary when the weights have the values shown.

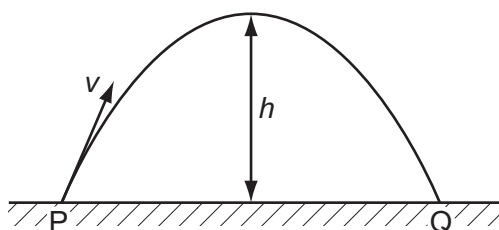


If the wheel is making 20 revolutions per second, what is the output power of the motor?

- A 300 W B 500 W C 600 W D 700 W

- 14 A ball of mass m is thrown up to height h in air with an initial velocity v , as shown.

9702/13/M/J/13



Air resistance is considered negligible. The acceleration of free fall is g .

What is the **total** work done by the gravitational force on the ball during its flight from P to Q?

- A zero B $\frac{1}{2}mv^2$ C mgh D $2mgh$

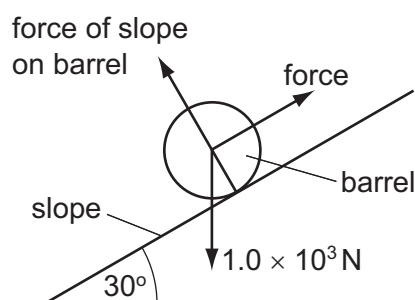
16 What is the internal energy of a system?

9702/11/O/N/13

- A the amount of heat supplied to the system
- B the random energy of the atoms of the system
- C the total kinetic energy of the system
- D the total potential energy of the system

17 The diagram shows a barrel of weight $1.0 \times 10^3 \text{ N}$ on a frictionless slope inclined at 30° to the horizontal.

9702/11/O/N/13



A force is applied to the barrel to move it up the slope at constant speed. The force is parallel to the slope.

What is the work done in moving the barrel a distance of 5.0 m up the slope?

- A $2.5 \times 10^3 \text{ J}$ B $4.3 \times 10^3 \text{ J}$ C $5.0 \times 10^3 \text{ J}$ D $1.0 \times 10^4 \text{ J}$

18 A car travelling on a level road at a steady 20 m s^{-1} against a constant resistive force develops a power of 40 kW.

9702/11/O/N/13

What is the magnitude of the resistive force?

- A 200 N B 800 N C 2000 N D 4000 N

19 A turbine at a hydroelectric power station is situated 30 m below the level of the surface of a large lake. The water passes through the turbine at a rate of 340 m^3 per minute.

9702/11/O/N/13

The overall efficiency of the turbine and generator system is 90%.

What is the output power of the power station? (The density of water is 1000 kg m^{-3} .)

- A 0.15 MW B 1.5 MW C 1.7 MW D 90 MW

17 The pump of a water pumping system uses 2.0 kW of electrical power when raising water. The pumping system lifts 16 kg of water per second through a vertical height of 7.0 m.

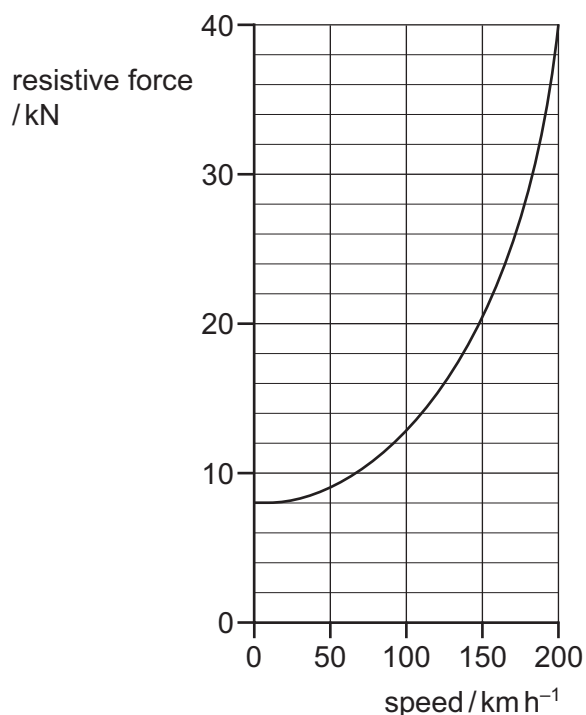
9702/13/O/N/13

What is the efficiency of the pumping system?

- A 1.8% B 5.6% C 22% D 55%

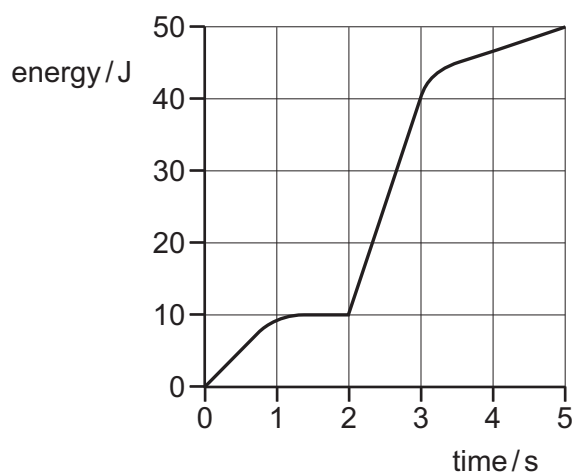
- 16** The graph shows how the total resistive force acting on a train varies with its speed. 9702/13/O/N/13

Part of this force is due to wheel friction, which is constant. The rest is due to wind resistance.



What is the ratio $\frac{\text{wind resistance}}{\text{wheel friction}}$ at a speed of 200 km h⁻¹?

- A** 4 **B** 5 **C** 8 **D** 10
- 19** An electrical generator is started at time zero. The total electrical energy generated during the first 5 seconds is shown in the graph. 9702/13/O/N/13



What is the maximum electrical power generated at any instant during these first 5 seconds?

- A** 10 W **B** 13 W **C** 30 W **D** 50 W

- 18** A body travelling with a speed of 20 m s^{-1} has kinetic energy E_k . 9702/13/O/N/13

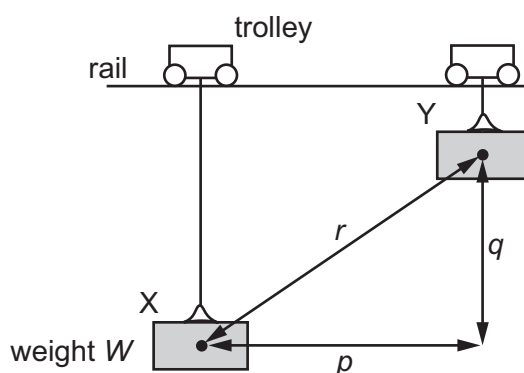
If the speed of the body is increased to 80 m s^{-1} , what is its new kinetic energy?

- A** $4E_k$ **B** $8E_k$ **C** $12E_k$ **D** $16E_k$

- 14** What is the average power output of a laser that can deliver 0.20 J of energy in 10 ns ? 9702/11/M/J/14

- A** 2 nW **B** 20 mW **C** 200 kW **D** 20 MW

- 15** A weight W hangs from a trolley that runs along a rail. The trolley moves horizontally through a distance p and simultaneously raises the weight through a height q . 9702/11/M/J/14



As a result, the weight moves through a distance r from X to Y . It starts and finishes at rest.

How much work is done on the weight during this process?

- A** Wp **B** $W(p + q)$ **C** Wq **D** Wr

- 16** The engine of a car exerts a force of 600 N in moving the car 1.0 km in 150 seconds. 9702/11/M/J/14

What is the average output power of the engine?

- A** 4.0 W **B** 4.0 kW **C** 90 kW **D** 90 MW

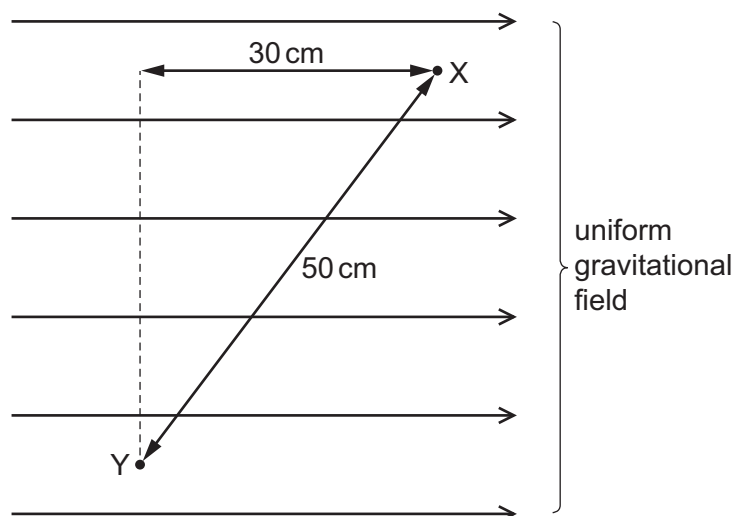
- 18** A ball drops onto a horizontal surface and bounces elastically. 9702/13/M/J/14

What happens to the kinetic energy of the ball during the very short time that it is in contact with the surface?

- A** Most of the kinetic energy is lost as heat and sound energy.
B The kinetic energy decreases to zero and then returns to its original value.
C The kinetic energy remains constant because it is an elastic collision.
D The kinetic energy remains constant in magnitude but changes direction.

- 14 A mass at point X inside a uniform gravitational field experiences a gravitational force of 0.200 N. It has 1.00 J of gravitational potential energy.

9702/12/M/J/14



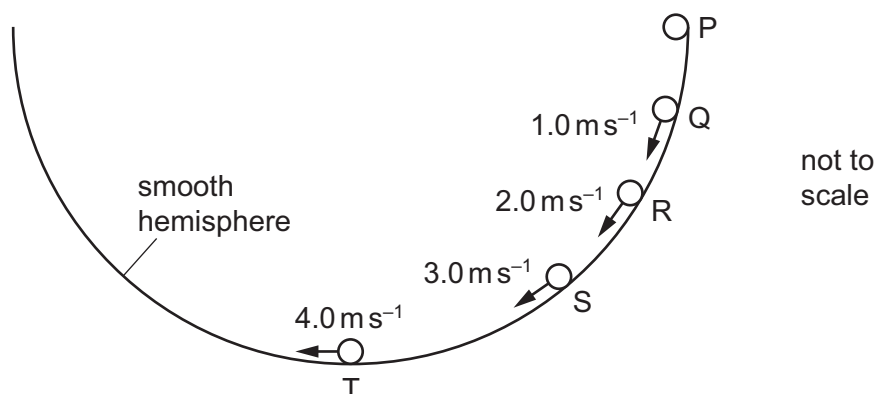
The mass is then moved to point Y.

What is its new gravitational potential energy?

- A 0.90 J B 0.94 J C 1.06 J D 1.10 J
- 15 A small mass is placed at point P on the inside surface of a smooth hemisphere. It is then released from rest. When it reaches the lowest point T, its speed is 4.0 m s^{-1} .

9702/12/M/J/14

The diagram (not to scale) shows the speed of the mass at other points Q, R and S as it slides down. Air resistance is negligible.



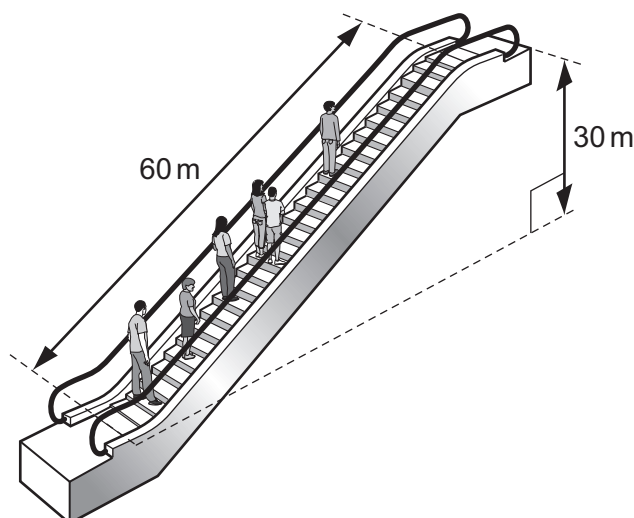
The mass loses potential energy E in falling from P to T.

At which point has the mass lost potential energy $\frac{E}{4}$?

- A Q
B R
C S
D none of these

- 16 An escalator is 60 m long and lifts passengers through a vertical height of 30 m, as shown.

9702/12/M/J/14



To drive the escalator against the forces of friction when there are no passengers requires a power of 2.0 kW.

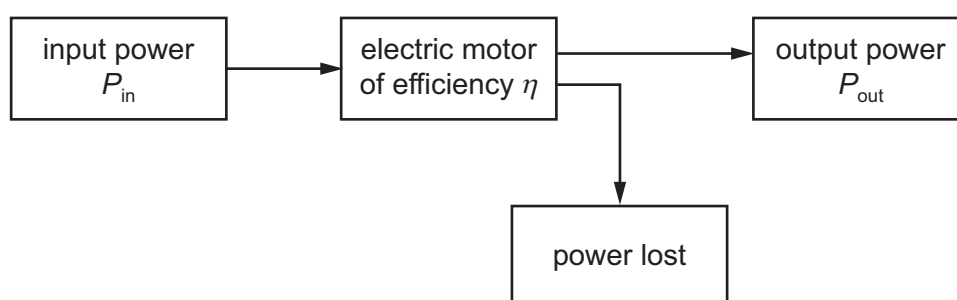
The escalator is used by passengers of average mass 60 kg and the power to overcome friction remains constant.

How much power is required to drive the escalator when it is carrying 20 passengers and is travelling at 0.75 m s^{-1} ?

- A 4.4 kW B 6.4 kW C 8.8 kW D 10.8 kW

- 16 An electric motor has an input power P_{in} , useful output power P_{out} and efficiency η .

9702/13/M/J/14



How much power is lost by the motor?

- A ηP_{in} B $\left(\frac{1}{\eta} - 1\right) P_{\text{in}}$ C ηP_{out} D $\left(\frac{1}{\eta} - 1\right) P_{\text{out}}$

- 17 A shot-put champion accelerates a 7.0 kg metal ball in a straight line. The ball moves from rest to a speed of 12 m s^{-1} in a distance of 1.2 m.

9702/13/M/J/14

What is the average resultant force on the metal ball?

- A 70 N B 210 N C 420 N D 840 N

Work, Energy and Power

Q. No.	Answer
1	D
2	C
3	D
4	D
5	B
6	C
7	D
8	C
9	C
10	C
11	B
12	D
13	B
14	D
15	B
16	A
17	C
18	A
19	B
20	A
21	A
22	B
23	B
24	D
25	C
26	C
27	B
28	A
29	D
30	A
31	A
32	C
33	B

34	C
35	B
36	C
37	C
38	C
39	B
40	C
41	A
42	A
43	D
44	C
45	B
46	A
47	D
48	C
49	A
50	D
51	C
52	B
53	D
54	D
55	B
56	B
57	B
58	D
59	C
60	D
61	D
62	B
63	D
64	D
65	B
66	D
67	D

68	A
69	B
70	C
71	D
72	C
73	C
74	B
75	C
76	A
77	B
78	B
79	D
80	C
81	B
82	A
83	C
84	A
85	C
86	B
87	C
88	B
89	D
90	D
91	B
92	D
93	B
94	B
95	D
96	C
97	B
98	A
99	D
100	D
101	A

102	A
103	A
104	C
105	D
106	A
107	D
108	B
109	B
110	B
111	B
112	B
113	B
114	A
115	C
116	A
117	A
118	B
119	A
120	C
121	B
122	D
123	A
124	C
125	D
126	D
127	C
128	B
129	B
130	C
131	B
132	B
133	D
134	C

Q1.

- 2 (a) (i) Define displacement.

.....
.....

- (ii) Use your definition to explain how it is possible for a car to travel a certain distance and yet have zero displacement.

.....
.....

[3]

- (b) A car starts from rest and travels upwards along a straight road inclined at an angle of 5.0° to the horizontal, as illustrated in Fig. 2.1.

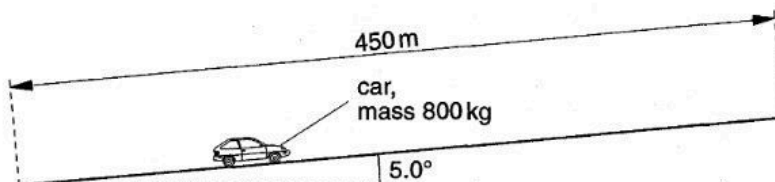


Fig. 2.1

The length of the road is 450 m and the car has mass 800 kg. The speed of the car increases at a constant rate and is 28 m s^{-1} at the top of the slope.

- (i) Determine, for this car travelling up the slope,

1. its acceleration,

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

2. the time taken to travel the length of the slope,

time taken = ... s [2]

3. the gain in kinetic energy,

gain in kinetic energy = ... J [2]

4. the gain in gravitational potential energy.

Us

gain in potential energy = ... J [3]

- (ii) Use your answers in (i) to determine the useful output power of the car.

power = ... W [3]

- (iii) Suggest one reason why the actual power output of the car engine is greater than that calculated in (ii).

.....
 [2]

Q2.

- 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.

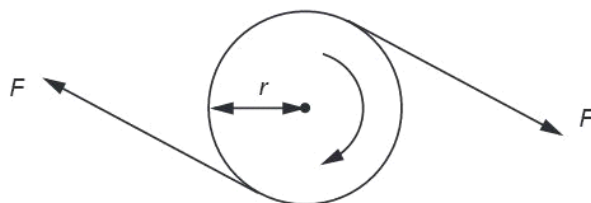


Fig. 5.1

- (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

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

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

Use

power = ... W [2]

Q3.

- 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.

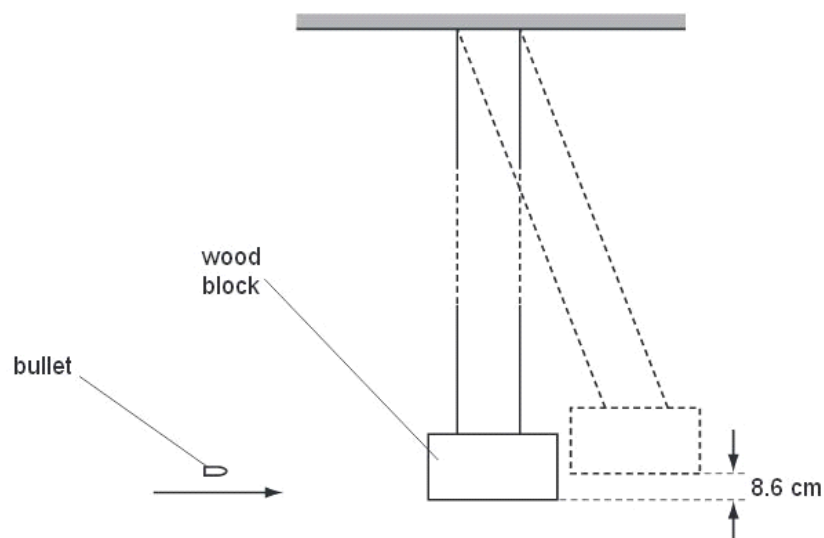


Fig. 3.1

- (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]

- (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]

Q4.

- 4 (a) A stone of mass 56 g is thrown horizontally from the top of a cliff with a speed of 18 m s^{-1} , as illustrated in Fig. 4.1.

Use

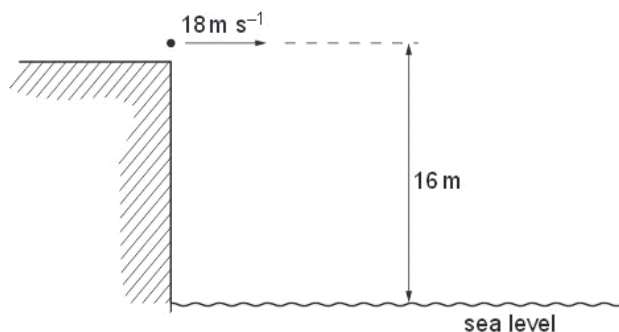


Fig. 4.1

The initial height of the stone above the level of the sea is 16 m. Air resistance may be neglected.

- (i) Calculate the change in gravitational potential energy of the stone as a result of falling through 16 m.

change = ... J [2]

- (ii) Calculate the total kinetic energy of the stone as it reaches the sea.

kinetic energy = ... J [3]

- (b) Use your answer in (a)(ii) to show that the speed of the stone as it hits the water is approximately 25 m s^{-1} .

[1]

- (c) State the horizontal velocity of the stone as it hits the water.

horizontal velocity = ... m s^{-1} [1]

- (d) (i) On the grid of Fig. 4.2, draw a vector diagram to represent the horizontal velocity and the resultant velocity of the stone as it hits the water. [1]

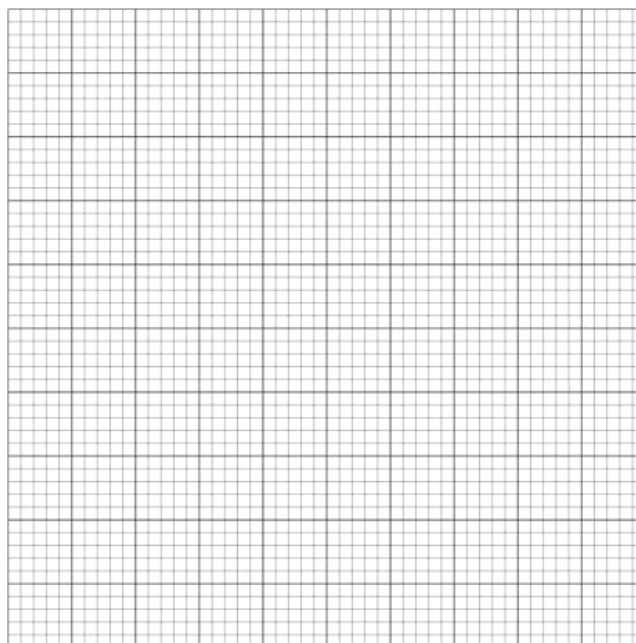


Fig. 4.2

- (ii) Use your vector diagram to determine the angle with the horizontal at which the stone hits the water.

angle = ... ° [2]

Q5.

- 3 (a) The variation with extension x of the tension F in a spring is shown in Fig. 3.1.

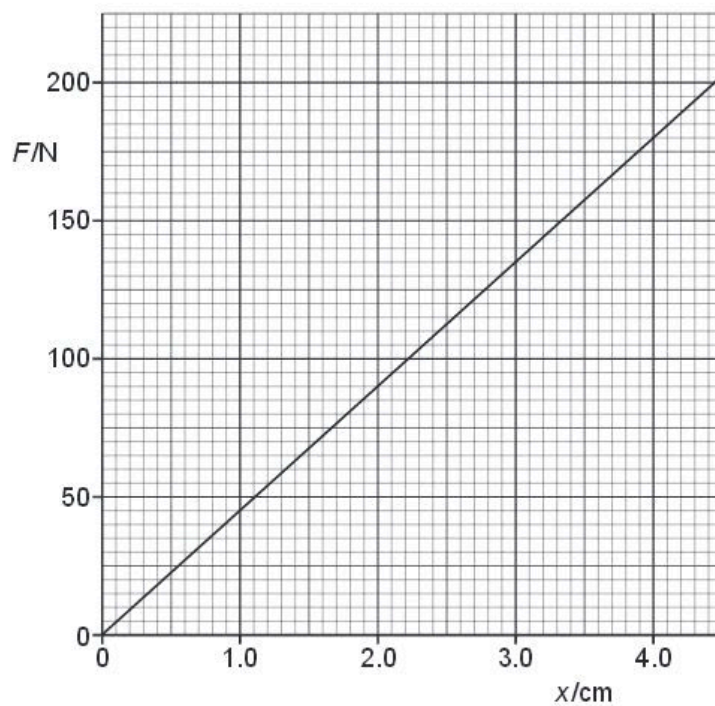


Fig. 3.1

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]

- (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.

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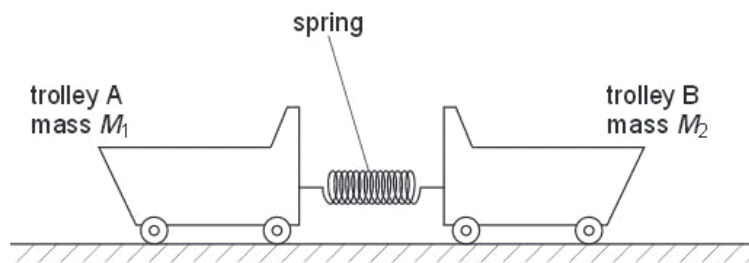


Fig. 3.2

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]

- (iii) 1. Show that the kinetic energy E_K of an object of mass m is related to its momentum p by the expression

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

[1]

2. Trolley A has a larger mass than trolley B.
Use your answer in (ii) part 1 to deduce which trolley, A or B, has the larger kinetic energy at the instant when the extension of the spring is zero.

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

Q6.

- 2 (a) Explain what is meant by *work done*.

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

- (b) A car is travelling along a road that has a uniform downhill gradient, as shown in Fig. 2.1.

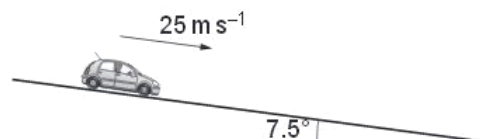


Fig. 2.1

The car has a total mass of 850 kg. The angle of the road to the horizontal is 7.5° .

Calculate the component of the weight of the car down the slope.

component of weight = ... N [2]

- (c) The car in (b) is travelling at a constant speed of 25 m s^{-1} . The driver then applies the brakes to stop the car. The constant force resisting the motion of the car is 4600 N.

- (i) Show that the deceleration of the car with the brakes applied is 4.1 m s^{-2} .

[2]

- (ii) Calculate the distance the car travels from when the brakes are applied until the car comes to rest.

distance = ... m [2]

(iii) Calculate

Ex 4

1. the loss of kinetic energy of the car,

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

2. the work done by the resisting force of 4600 N.

work done = ... J [1]

(iv) The quantities in **(iii) part 1** and in **(iii) part 2** are not equal. Explain why these two quantities are not equal.

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

Q7.

- 3 A cyclist is moving up a slope that has a constant gradient. The cyclist takes 8.0 s to climb the slope.
The variation with time t of the speed v of the cyclist is shown in Fig. 3.1.

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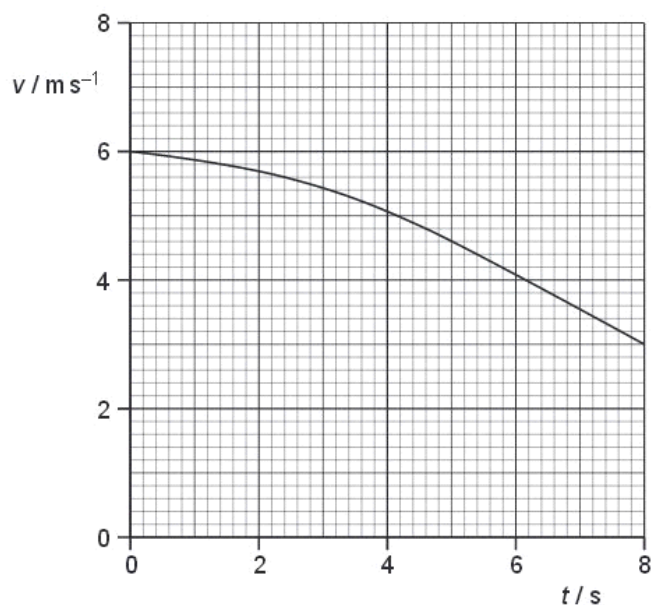


Fig. 3.1

- (a) Use Fig. 3.1 to determine the total distance moved up the slope.

distance = ... m [3]

- (b)** The bicycle and cyclist have a combined mass of 92 kg.
The vertical height through which the cyclist moves is 1.3 m.

Ex

- (i)** For the movement of the bicycle and cyclist between $t = 0$ and $t = 8.0$ s,

1. use Fig. 3.1 to calculate the change in kinetic energy,

change = ... J [2]

2. calculate the change in gravitational potential energy.

change = ... J [2]

- (ii)** The cyclist pedals continuously so that the useful power delivered to the bicycle is 75 W.

Calculate the useful work done by the cyclist climbing up the slope.

work done = ... J [2]

(c) Some energy is used in overcoming frictional forces.

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- (i) Use your answers in (b) to show that the total energy converted in overcoming frictional forces is approximately 670 J.

[1]

- (ii) Determine the average magnitude of the frictional forces.

average force = ...N [1]

- (d) Suggest why the magnitude of the total resistive force would not be constant.

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

Q8.

- 3 (a) (i) Explain what is meant by *work done*.

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

- (ii) Define *power*.

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

- (b) Fig. 3.1 shows part of a fairground ride with a carriage on rails.

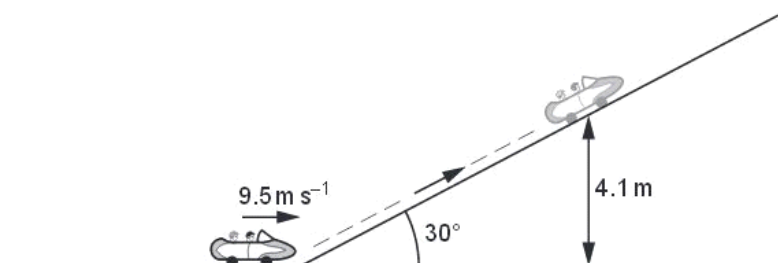


Fig. 3.1

The carriage and passengers have a total mass of 600 kg. The carriage is travelling at a speed of 9.5 m s^{-1} towards a slope inclined at 30° to the horizontal. The carriage comes to rest after travelling up the slope to a vertical height of 4.1 m.

- (i) Calculate the kinetic energy, in kJ, of the carriage and passengers as they travel towards the slope.

kinetic energy = ... kJ [3]

- (ii) Show that the gain in potential energy of the carriage and passengers is 24 kJ.

[2]

- (iii) Calculate the work done against the resistive force as the carriage moves up the slope.

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work done = ... kJ [1]

- (iv) Use your answer in (iii) to calculate the resistive force acting against the carriage as it moves up the slope.

resistive force = ... N [2]

Q9.

- 2 (a) A ball is thrown vertically down towards the ground and rebounds as illustrated in Fig. 2.1.

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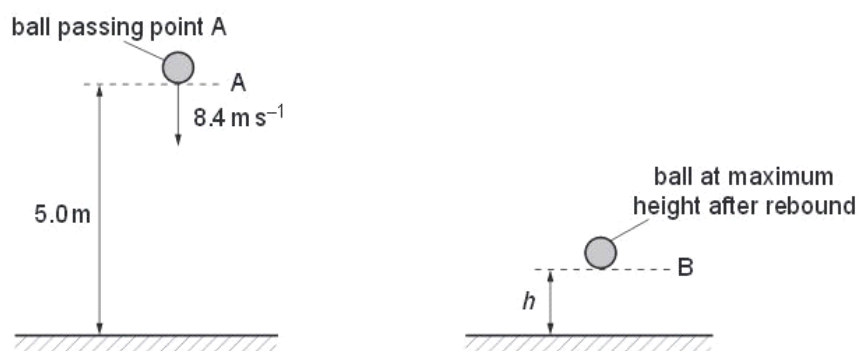


Fig. 2.1

As the ball passes A, it has a speed of 8.4 m s^{-1} . The height of A is 5.0m above the ground. The ball hits the ground and rebounds to B. Assume that air resistance is negligible.

- (i) Calculate the speed of the ball as it hits the ground.

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

- (ii) Show that the time taken for the ball to reach the ground is 0.47 s.

[1]

- (b) The ball rebounds vertically with a speed of 4.2 m s^{-1} as it leaves the ground. The time the ball is in contact with the ground is 20 ms. The ball rebounds to a maximum height h .

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The ball passes A at time $t = 0$. On Fig. 2.2, plot a graph to show the variation with time t of the velocity v of the ball. Continue the graph until the ball has rebounded from the ground and reaches B.

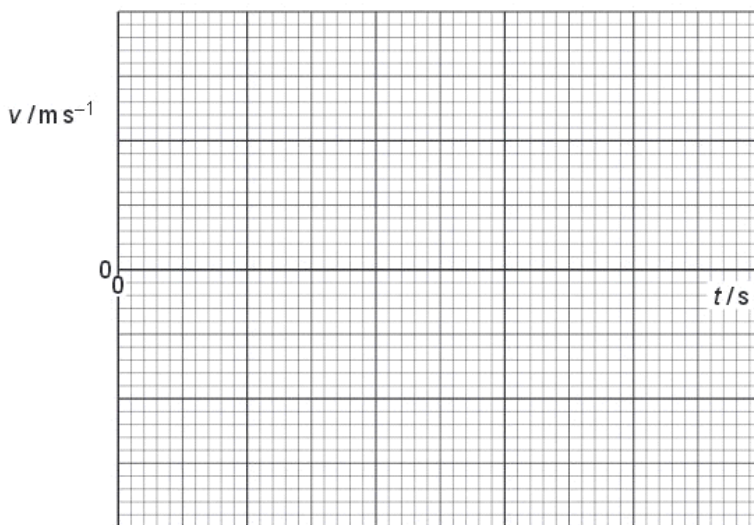


Fig. 2.2

[3]

(c) The ball has a mass of 0.050 kg. It moves from A and reaches B after rebounding.

(i) For this motion, calculate the change in

1. kinetic energy,

change in kinetic energy = ... J [2]

2. gravitational potential energy.

change in potential energy = ... J [3]

(ii) State and explain the total change in energy of the ball for this motion.

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

Ex

Q10.

- 3 (a) An object falls vertically from rest through air. State and explain the energy conversions that occur as the object falls.

Ex.

.....

 [3]

- (b) A ball of mass 150 g is thrown vertically upwards with an initial speed of 25 m s^{-1} .

- (i) Calculate the initial kinetic energy of the ball.

kinetic energy = ... J [3]

- (b) A ball of mass 150 g is thrown vertically upwards with an initial speed of 25 m s^{-1} .

- (i) Calculate the initial kinetic energy of the ball.

kinetic energy = ... J [3]

- (ii) The ball reaches a height of 21 m above the point of release.

For the ball rising to this height, calculate

1. the loss of energy of the ball to air resistance,

energy loss = ... J [3]

2. the average force due to the air resistance.

force = ... N [2]

Q11.

- 4 (a) Explain what is meant by the concept of *work*.

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

- (b) Using your answer to (a), derive an expression for the increase in gravitational potential energy ΔE_p when an object of mass m is raised vertically through a distance Δh near the Earth's surface.

The acceleration of free fall near the Earth's surface is g . [2]

Q12.

- 8 (a) Explain the concept of *work*.

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

Ex6

- (b) A table tennis ball falls vertically through air. Fig. 8.1 shows the variation of the kinetic energy E_K of the ball with distance h fallen. The ball reaches the ground after falling through a distance h_0 .

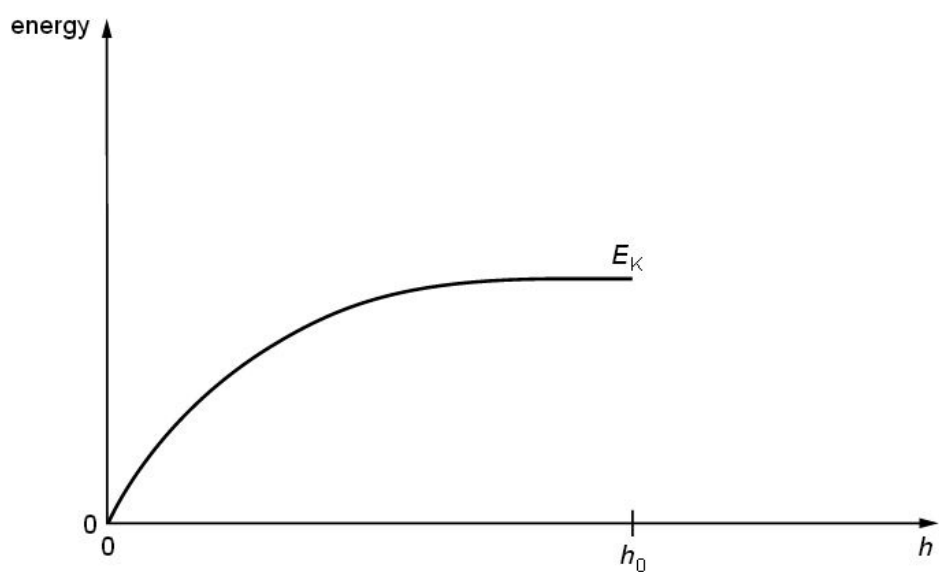


Fig. 8.1

- (i) Describe the motion of the ball.

.....

.....

.....

.....

..... [3]

- (ii) On Fig. 8.1, draw a line to show the variation with h of the gravitational potential energy E_P of the ball. At $h = h_0$, the potential energy is zero. [3]

Q13.

1 (a) Define what is meant by

(i) *work done*,

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

(ii) *power*.

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

(b) A force F is acting on a body that is moving with velocity v in the direction of the force.

Derive an expression relating the power P dissipated by the force to F and v .

[2]

(c) A car of mass 1900 kg accelerates from rest to a speed of 27 m s^{-1} in 8.1 s.

(i) Calculate the average rate at which kinetic energy is supplied to the car during the acceleration.

rate = ... W [2]

- (ii) The car engine provides power at a constant rate. Suggest and explain why the acceleration of the car is **not** constant.

.....

 [2]

Q14.

- 3 (a) (i) Define potential energy.

.....
 [1]

- (ii) Distinguish between *gravitational* potential energy and *elastic* potential energy.

gravitational potential energy

.....

elastic potential energy

..... [2]

- (b) A small sphere of mass 51 g is suspended by a light inextensible string from a fixed point P.
 The centre of the sphere is 61 cm vertically below point P, as shown in Fig. 3.1.

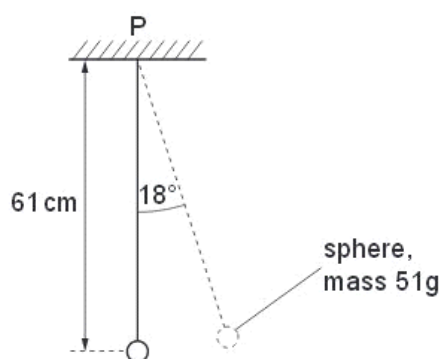


Fig. 3.1

The sphere is moved to one side, keeping the string taut, so that the string makes an angle of 18° with the vertical. Calculate

(i) the gain in gravitational potential energy of the sphere,

gain = ... J [2]

(ii) the moment of the weight of the sphere about point P.

moment = ... N m [2]

Q15.

- 4 (a) Distinguish between *gravitational potential energy* and *electric potential energy*.

For
Examiner's
Use

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

- (b) A body of mass m moves vertically through a distance h near the Earth's surface. Use the defining equation for work done to derive an expression for the gravitational potential energy change of the body.

[2]

- (c) Water flows down a stream from a reservoir and then causes a water wheel to rotate, as shown in Fig. 4.1.

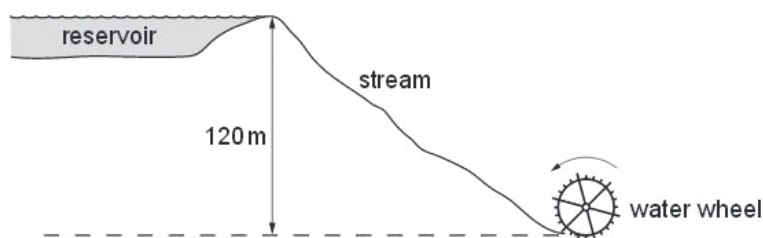


Fig. 4.1

As the water falls through a vertical height of 120m, gravitational potential energy is converted to different forms of energy, including kinetic energy of the water. At the water wheel, the kinetic energy of the water is only 10% of its gravitational potential energy at the reservoir.

- (i) Show that the speed of the water as it reaches the wheel is 15 m s^{-1} .

[2]

- (ii) The rotating water wheel is used to produce 110 kW of electrical power. Calculate the mass of water flowing per second through the wheel, assuming that the production of electric energy from the kinetic energy of the water is 25% efficient.

mass of water per second = ... kg s^{-1} [3]

Q16.

- 3 (a) Define the terms

- (i) *power*,

.....[1]

- (ii) the *Young modulus*.

.....

[1]

For
Examin
Use

(b) A crane is used to lift heavy objects, as shown in Fig. 3.1.

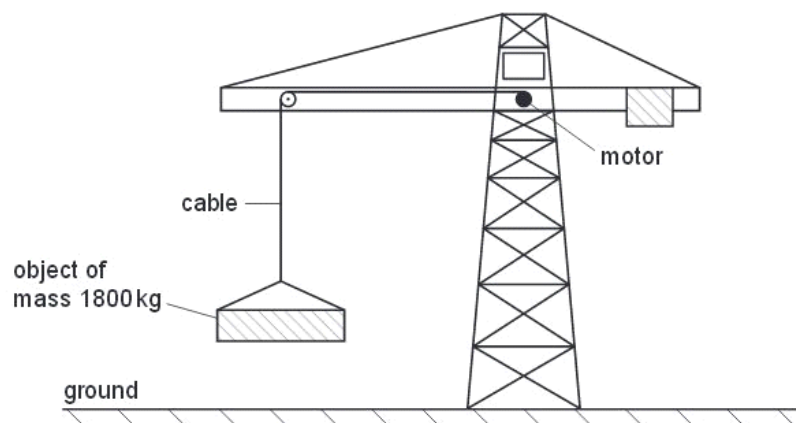


Fig. 3.1

The motor in the crane lifts a total mass of 1800 kg from rest on the ground. The cable supporting the mass is made of steel of Young modulus $2.4 \times 10^{11} \text{ Pa}$. The cross-sectional area of the cable is $1.3 \times 10^{-4} \text{ m}^2$. As the mass leaves the ground, the strain in the cable is 0.0010. Assume the weight of the cable to be negligible.

- (i) 1. Use the Young Modulus of the steel to show that the tension in the cable is $3.1 \times 10^4 \text{ N}$.

[2]

2. Calculate the acceleration of the mass as it is lifted from the ground.

acceleration = ... m s^{-2} [3]

- (ii) The motor now lifts the mass through a height of 15 m at a constant speed.

Calculate

1. the tension in the lifting cable,

tension = ... N [1]

2. the gain in potential energy of the mass.

gain in potential energy = ... J [2]

- (iii) The motor of the crane is 30% efficient. Calculate the input power to the motor required to lift the mass at a constant speed of 0.55 m s^{-1} .

input power = ... W [3]

Q17.

- 3 (a) State what is meant by *work done*.

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

- (b) A trolley of mass 400 g is moving at a constant velocity of 2.5 m s^{-1} to the right as shown in Fig. 3.1.



Fig. 3.1

Show that the kinetic energy of the trolley is 1.3 J.

[2]

- (c) The trolley in (b) moves to point P as shown in Fig. 3.2.

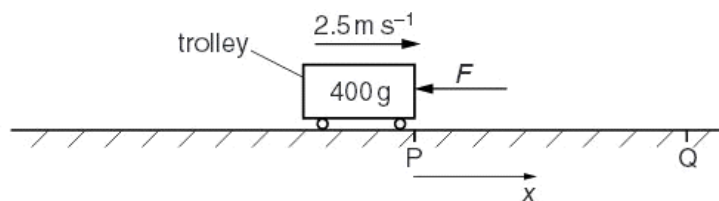


Fig. 3.2

At point P the speed of the trolley is 2.5 m s^{-1} .

A variable force F acts to the left on the trolley as it moves between points P and Q.
The variation of F with displacement x from P is shown in Fig. 3.3.

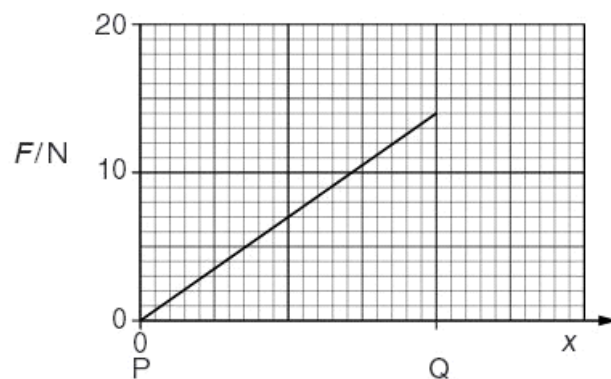


Fig. 3.3

The trolley comes to rest at point Q.

- (i) Calculate the distance PQ.

For
Examiners

distance PQ = ... m [3]

- (ii) On Fig. 3.4, sketch the variation with x of velocity v for the trolley moving between P and Q.

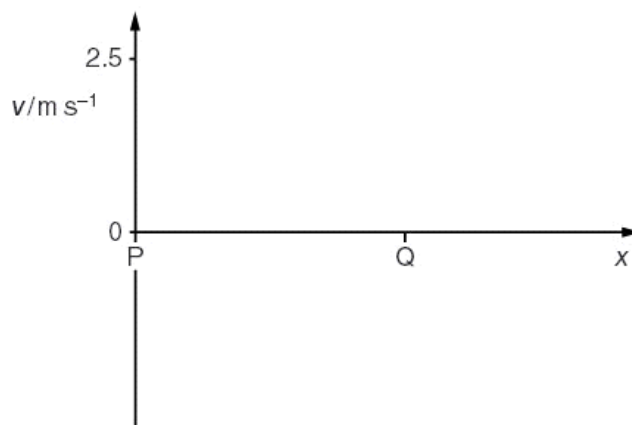


Fig. 3.4

[2]

Q18.

- 4 (a) Distinguish between gravitational potential energy and elastic potential energy.

Exa

.....

[2]

- (b) A ball of mass 65 g is thrown vertically upwards from ground level with a speed of 16 m s^{-1} . Air resistance is negligible.

- (i) Calculate, for the ball,

1. the initial kinetic energy,

kinetic energy = ... J [2]

2. the maximum height reached.

maximum height = ... m [2]

- (ii) The ball takes time t to reach maximum height. For time $\frac{t}{2}$ after the ball has been thrown, calculate the ratio

$$\frac{\text{potential energy of ball}}{\text{kinetic energy of ball}} .$$

ratio = ... [3]

- (iii) State and explain the effect of air resistance on the time taken for the ball to reach maximum height.

.....

.....

.....[1]

Q1.

- 2 (a) (i)** distance from a (fixed) point.....M1
in a specified direction A1
(Allow 1 mark for 'distance in a given direction')
- (ii)** (displacement from start is zero if) car at its starting position..... B1 [3]
- (b) (i)1** $v^2 = u^2 + 2as$
 $28^2 = 2 \times a \times 450$ (use of component of 450 scores no marks)..... C1
 $a = 0.87 \text{ m s}^{-2}$ A1 [2]
(-1 for 1 sig. fig. but once only in the question)
- (i)2** $v = u + at$ or any appropriate equation
 $28 = 0.87t$ or appropriate substitution..... C1
 $t = 32 \text{ s}$ A1 [2]
- (i)3** $E_k = \frac{1}{2}mv^2$ C1
 $= \frac{1}{2} \times 800 \times 28^2$
 $= 3.14 \times 10^5 \text{ J}$ A1 [2]
- (i)4** $E_p = mgh$ C1
 $= 800 \times 9.8 \times 450 \sin 5$ C1
 $= 3.07 \times 10^5 \text{ J}$ A1 [3]
- (ii)** power = energy/time C1
 $= (6.21 \times 10^5)/32.2$ C1
 $= 1.93 \times 10^4 \text{ W}$ A1 [3]
(power = Fv with $F = mg \sin \theta$ scores no marks)
- (iii)** some work also done against friction forces.....M1
location of frictional forces identified A1 [2]
- (allow reasonable alternatives)

Q2.

- 5 (a) (i)** distance = $2\pi nr$ B1
(ii) work done = $F \times 2\pi nr$ (accept e.c.f.) B1 [2]
- (b)** total work done = $2 \times F \times 2\pi nr$ B1
but torque $T = 2Fr$ B1
hence work done = $T \times 2\pi n$ A0 [2]
- (c)** power = work done/time (= $470 \times 2\pi \times 2400/60$)
 $= 1.2 \times 10^5 \text{ W}$ A1 [2]
- Total** [6]

Q3.

3	(a) (i)	$\Delta E_p = mgh$ $= 0.602 \times 9.8 \times 0.086$ $= 0.51 \text{ J}$ (do not allow $g = 10$, $m = 0.600$ or answer 0.50 J)	C1	
			A1	[2]
	(ii)	$v^2 = (2gh) \Rightarrow 2 \times 9.8 \times 0.086$ or $(2 \times 0.51)/0.602$ $v = 1.3 \text{ (m s}^{-1}\text{)}$	M1 A0	[1]
	(b)	$2 \times V = 602 \times 1.3$ (allow 600) $V = 390 \text{ m s}^{-1}$	C1 A1	[2]
	(c) (i)	$E_k = \frac{1}{2}mv^2$ $= \frac{1}{2} \times 0.002 \times 390^2$ $= 152 \text{ J or } 153 \text{ J or } 150 \text{ J}$	C1 A1	[2]
	(ii)	E_k not the same/changes or E_k before impact $> E_k$ after/ E_p after so must be inelastic collision (allow 1 mark for 'bullet embeds itself in block' etc.)	M1 A1	[2]

Q4.

4	(a) (i)	(change in) potential energy $= mgh$ $= 0.056 \times 9.8 \times 16$ $= 8.78 \text{ J}$ (allow 8.8)	C1	
			A1	[2]
	(ii)	(initial) kinetic energy $= \frac{1}{2}mv^2$ $= \frac{1}{2} \times 0.056 \times 18^2$ $= 9.07 \text{ J}$ (allow 9.1) total kinetic energy $= 8.78 + 9.07 = 17.9 \text{ J}$	C1 C1 A1	[3]
	(b)	kinetic energy $= \frac{1}{2}mv^2$ $17.9 = \frac{1}{2} \times 0.056 \times v^2$ and $v = 25(.3) \text{ m s}^{-1}$	B1	[1]
	(c)	horizontal velocity $= 18 \text{ m s}^{-1}$	B1	[1]
	(d) (i)	correct shape of diagram (two sides of right-angled triangle with correct orientation)	B1	
	(ii)	angle $= 41^\circ \rightarrow 48^\circ$ (allow triq. solution based on diagram) (for angle $38^\circ \rightarrow 41^\circ$ or $48^\circ \rightarrow 51^\circ$, allow 1 mark)	A2	[3]

Q5.

- 3 (a) *either* energy (stored)/work done represented by area under graph
or energy = average force $\times$ extension B1
energy = $\frac{1}{2} \times 180 \times 4.0 \times 10^{-2}$ C1
= 3.6 J A1 [3]
- (b) (i) *either* momentum before release is zero M1
so sum of momenta (of trolleys) after release is zero A1
or force = rate of change of momentum (M1)
force on trolleys equal and opposite (A1)
or impulse = change in momentum (M1)
impulse on each equal and opposite (A1) [2]
- (ii) 1 $M_1 V_1 = M_2 V_2$ B1 [1]
2 $E = \frac{1}{2} M_1 V_1^2 + \frac{1}{2} M_2 V_2^2$ B1 [1]
- (iii) 1 $E_k = \frac{1}{2} m v^2$ and $p = m v$ combined to give M1
 $E_k = p^2 / 2m$ A0 [1]
2 m smaller, E_k is larger because p is the same/constant M1
so trolley B A0 [1]

Q6.

- 2 (a) work done is the force $\times$ the distance moved / displacement in the direction of the force
or
work is done when a force moves in the direction of the force B1 [1]
- (b) component of weight = $850 \times 9.81 \times \sin 7.5^\circ$ C1
= 1090 N A1 [2]
(use of incorrect trigonometric function, 0/2)
- (c) (i) $\Sigma F = 4600 - 1090 = (3510)$ M1
deceleration = $3510 / 850$ A1
= 4.1 ms^{-2} A0 [2]
- (ii) $v^2 = u^2 + 2as$
 $0 = 25^2 + 2 \times -4.1 \times s$ C1
 $s = 625 / 8.2$
= 76 m A1 [2]
(allow full credit for calculation of time (6.05 s) & then s)
- (iii) 1. kinetic energy = $\frac{1}{2} m v^2$ C1
= $0.5 \times 850 \times 25^2$
= $2.7 \times 10^5 \text{ J}$ A1 [2]
2. work done = 4600×75.7
= $3.5 \times 10^5 \text{ J}$ A1 [1]
- (iv) difference is the loss in potential energy (owtte) B1 [1]

Q7.

3	(a)	evidence of use of area below the line distance = 39 m (allow ± 0.5 m) (if $> \pm 0.5$ m but ≤ 1.0 m, then allow 1 mark)	B1 A2	[3]
(b)	(i)	1 $E_k = \frac{1}{2}mv^2$ $\Delta E_k = \frac{1}{2} \times 92 \times (6^2 - 3^2)$ = 1240 J	C1 A1	[2]
		2 $E_p = mgh$ $\Delta E_p = 92 \times 9.8 \times 1.3$ = 1170 J	C1 A1	[2]
	(ii)	$E = Pt$ $E = 75 \times 8$ = 600 J	C1 A1	[2]
(c)	(i)	energy = $(1240 + 600) - 1170$ = 670 J	M1 A0	[1]
	(ii)	force = $670/39 = 17$ N	A1	[1]
(d)		frictional forces include air resistance air resistance decreases with decrease of speed	B1 B1	[2]

Q8.

3	(a)	(i) work done equals force $\times$ distance moved / displacement in the direction of the force	B1	[1]
		(ii) power is the rate of doing work / work done per unit time	B1	[1]
(b)	(i)	kinetic energy = $\frac{1}{2}mv^2$ = $0.5 \times 600 (9.5)^2$ = 27075 (J) = 27 kJ	C1 C1 A1	[3]
	(ii)	potential energy = mgh = $600 \times 9.81 \times 4.1$ = 24132 (J) = 24 kJ	M1 A1 A0	[2]
	(iii)	work done = $27 - 24 = 3.0$ kJ	A1	[1]
	(iv)	resistive force = $3000 / 8.2$ (distance along slope = $4.1 / \sin 30^\circ$) = 366 N	C1 A1	[2]

Q9.

2	(a)	(i)	$v^2 = u^2 + 2as$ $= (8.4)^2 + 2 \times 9.81 \times 5$ $= 12.99 \text{ ms}^{-1}$ (allow 13 to 2 s.f. but not 12.9)	C1 A1	[2]
		(ii)	$t = (v - u) / a$ or $s = ut + \frac{1}{2}at^2$ $= (12.99 - 8.4) / 9.81$ or $5 = 8.4t + \frac{1}{2} \times 9.81t^2$ $t = 0.468 \text{ s}$	M1 A0	[1]
	(b)	reasonable shape suitable scale correctly plotted 1 st and last points at (0,8.4) and (0.88 – 0.96,0) with non-vertical line at 0.47 s	M1 A1 A1	[3]	
	(c)	(i)	1. kinetic energy at end is zero so $\Delta KE = \frac{1}{2}mv^2$ or $\Delta KE = \frac{1}{2}mu^2 - \frac{1}{2}mv^2$ $= \frac{1}{2} \times 0.05 \times (8.4)^2$ $= (-) 1.8 \text{ J}$	C1 A1	[2]
			2. final maximum height $= (4.2)^2 / (2 \times 9.8) = (0.9 \text{ (m)})$ change in PE $= mgh_2 - mgh_1$ $= 0.05 \times 9.8 \times (0.9 - 5)$ $= (-) 2.0 \text{ J}$	C1 C1 A1	[3]
		(ii)	change is – 3.8 (J) energy lost to ground (on impact) / energy of deformation of the ball / thermal energy in ball	B1 B1	[2]

Q10.

3	(a)	loss in potential energy due to decrease in height (as P.E. = mgh) gain in kinetic energy due to increase in speed (as K.E. = $\frac{1}{2}mv^2$) <i>special case 'as PE decreases KE increases' (1/2)</i> increase in thermal energy due to work done against air resistance loss in P.E. equals gain in K.E. and thermal energy	(B1) (B1) (B1) (B1) max. 3	[3]
(b)	(i)	kinetic energy $= \frac{1}{2}mv^2$ $= \frac{1}{2} \times 0.150 \times (25)^2$ $= 46.875 = 47 \text{ J}$	C1 C1 A1	[3]
(ii)	1.	potential energy ($= mgh$) $= 0.150 \times 9.81 \times 21$ loss $= KE - mgh = 46.875 - (30.9)$ $= 15.97 = 16 \text{ J}$	C1 C1 A1	[3]
		2. work done = 16 J work done = force $\times$ distance $F = 16 / 21 = 0.76 \text{ N}$	C1 A1	[2]

Q11.

- 4 (a) force $\times$ distance moved M1
in the direction of the force A1 [2]
- (b) weight / force = mg M1
 $\Delta E_p = mg \times \Delta h$ A1 [2]
(no marks for quote of $mg\Delta h$)

Q12.

- 8 (a) product of force and distance M1
moved in the direction of the force A1 [2]
- (b) (i) falls from rest B1
decreasing acceleration B1
reaches a constant speed B1 [3]
- (ii) straight line with negative gradient B1
y-axis intercept above maximum E_k B1
reasonable gradient (same magnitude as that for E_k initially) B1 [3]

Q13.

- 1 (a) (i) product of force and distance moved M1
(by force) in the direction of the force A1 [2]
(ii) work (done) per unit time (*idea of ratio needed*) B1 [1]
- (b) *either* work/time or power = (force $\times$ distance)/time M1
to give power = force $\times$ velocity A1 [2]
- (c) (i) kinetic energy ($= \frac{1}{2}mv^2$) = $\frac{1}{2} \times 1900 \times 27^2$ C1
power = $692550 / 8.1 = 8.55 \times 10^4$ W A1 [2]
(ii) *either* for equal increments of speed, increments of E_k are different M1
so longer time (to increase speed) at high speeds A1 [2]
or air resistance increases with speed (M1)
so driving force (and acceleration) reduced (A1)
or $P (= Fv) = mav$ (M1)
(P and m constant) so when v increases, a decreases (A1)

Q14.

- 3 (a) (i) potential energy: stored energy available to do work B1 [1]
- (ii) gravitational: due to height/position of mass OR distance from mass B1
 OR moving mass from one point to another B1 [2]
 elastic: due to deformation/stretching/compressing
- (b) (i) height raised = $(61 - \{61 \cos 18\}) = 3.0 \text{ cm}$ C1
 energy = $(mgh = 0.051 \times 9.8 \times 0.030 =) 1.5 \times 10^{-2} \text{ J}$ A1 [2]
- (ii) moment = force $\times$ perpendicular distance C1
 $= 0.051 \times 9.8 \times 0.61 \times \sin 18$ A1 [2]
 $= 0.094 \text{ N m}$

Q15.

- 4 (a) electrical potential energy (stored) when charge moved and gravitational potential energy (stored) when mass moved B1
 due to work done in electric field and work done in gravitational field B1 [2]
- (b) work done = force $\times$ distance moved (in direction of force) M1
 and force = mg A1 [2]
 $mg \times h$ or $mg \times \Delta h$
- (c) (i) $0.1 \times mgh = \frac{1}{2} mv^2$ B1
 $0.1 \times m \times 9.81 \times 120 = 0.5 \times m \times v^2$ B1
 $v = 15.3 \text{ ms}^{-1}$ A0 [2]
- (ii) $P = 0.5 m v^2 / t$ C1
 $m / t = 110 \times 10^3 / [0.25 \times 0.5 \times (15.3)^2]$ C1
 $= 3740 \text{ kg s}^{-1}$ A1 [3]

Q16.

- 3 (a) (i) power = work done per unit time / energy transferred per unit time / rate of work done B1 [1]
- (ii) Young modulus = stress / strain B1 [1]
- (b) (i) 1. $E = T / (A \times \text{strain})$ (allow strain = ϵ) C1
 $T = E \times A \times \text{strain} = 2.4 \times 10^{11} \times 1.3 \times 10^{-4} \times 0.001$ M1
 $= 3.12 \times 10^4 \text{ N}$ A0 [2]
2. $T - W = ma$ C1
 $[3.12 \times 10^4 - 1800 \times 9.81] = 1800a$ C1
 $a = 7.52 \text{ ms}^{-2}$ A1 [3]
- (ii) 1. $T = 1800 \times 9.81 = 1.8 \times 10^4 \text{ N}$ A1 [1]
2. potential energy gain = mgh C1
 $= 1800 \times 9.81 \times 15$
 $= 2.7 \times 10^5 \text{ J}$ A1 [2]
- (iii) $P = Fv$ C1
 $= 1800 \times 9.81 \times 0.55$ C1
input power = $9712 \times (100/30) = 32.4 \times 10^3 \text{ W}$ A1 [3]

Q17.

- 3 (a) (work =) force $\times$ distance moved / displacement in the direction of the force OR when a force moves in the direction of the force work is done B1 [1]
- (b) kinetic energy = $\frac{1}{2} mv^2$ C1
 $= \frac{1}{2} 0.4 (2.5)^2 = 1.25 / 1.3 \text{ J}$ A1 [2]
- (c) (i) area under graph is work done / work done = $\frac{1}{2} Fx$ C1
 $1.25 = (14 x) / 2$ C1
 $x = 0.18 (0.179) \text{ m}$ [allow $x = 0.19 \text{ m}$ using kinetic energy = 1.3 J] A1 [3]
- (ii) smooth curve from $v = 2.5$ at $x = 0$ to $v = 0$ at Q M1
curve with increasing gradient A1 [2]

Q18.

- 4 (a) gravitational PE is energy of a mass due to its position in a gravitational field B1
 elastic PE energy stored (in an object) due to (a force) changing its shape /
 deformation / being compressed / stretched / strained B1 [2]
- (b) (i) 1. kinetic energy = $\frac{1}{2}mv^2$ C1
 $= \frac{1}{2} \times 0.065 \times 16^2 = 8.3(2)$ J A1 [2]
2. $v^2 = 2gh$ OR $PE = mgh$ C1
 $h = 16^2 / (2 \times 9.81) = 13(05)$ m A1 [2]
- (ii) speed at $t = \frac{1}{2}$ total time = $8 \text{ (ms}^{-1}\text{)}$ or total $t = 1.63$ or $t_{1/2} = 0.815$ s C1
 KE is $\frac{1}{4}$ or h at $t_{1/2} = 9.78$ (m) C1
 and PE is $\frac{3}{4}$ of max ratio = 3 or ratio = $9.78 / 3.26 = 3$ A1 [3]
- (iii) time is less because (average) acceleration is greater OR average force
 is greater B1 [1]

1. June/2021/Paper_11/No.15

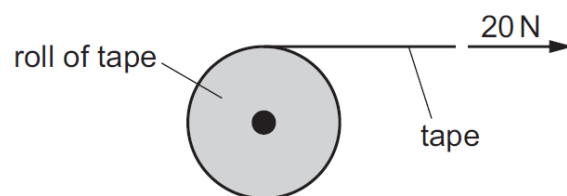
A rocket is fired upwards.

As it accelerates upwards after leaving the launch pad, which forms of energy are changing?

- A** chemical energy, gravitational potential energy and kinetic energy
- B** chemical energy and gravitational potential energy only
- C** chemical energy and kinetic energy only
- D** gravitational potential energy and kinetic energy only

2. June/2021/Paper_11/No.16

A roll of tape of length 50 m requires a constant force of 20 N to unwrap it.

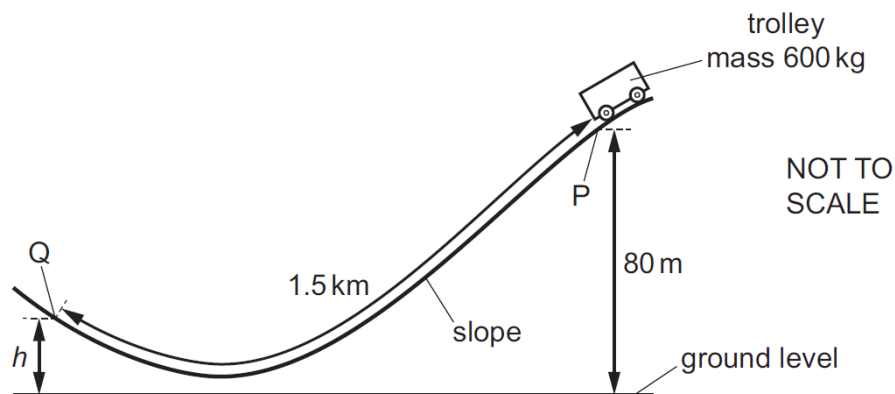


What is the work done in unwrapping the whole roll?

- A** 0.4 J
- B** 2.5 J
- C** 500 J
- D** 1000 J

3. June/2021/Paper_11/No.17

A trolley of mass 600 kg is initially at point P on a slope, at a height of 80 m above ground level, as shown. The trolley is released from rest and moves along the slope, first coming to rest at point Q, at height h above ground level.



The total distance PQ moved by the trolley along the slope is 1.5 km. A constant resistive force of 300 N opposes the motion of the trolley on the slope.

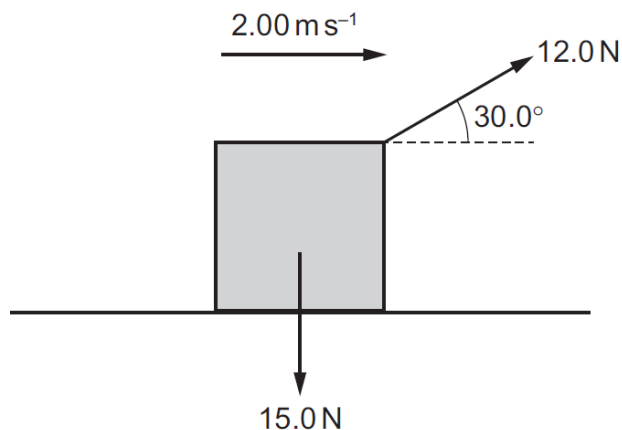
What is h ?

- A** 3.5 m
- B** 76 m
- C** 79 m
- D** 80 m

4. [June/2021/Paper_11/No.18](#)

An object of weight 15.0 N is pulled along a horizontal surface at a constant velocity of 2.00 m s^{-1} .

The force pulling the object is 12.0 N at 30.0° to the horizontal, as shown.



What is the power used to move the object?

- A** 12.0 W **B** 20.8 W **C** 24.0 W **D** 30.0 W

5. [June/2021/Paper_12/No.15](#)

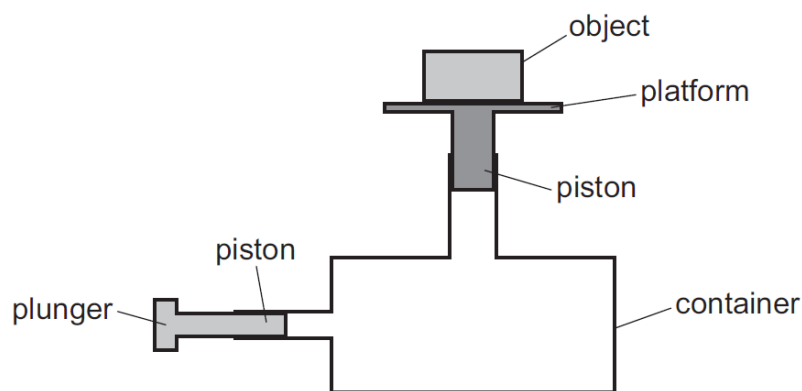
A stone is falling vertically through the air at a constant (terminal) velocity.

Which energy change is occurring?

- A** gravitational potential energy to thermal energy
B gravitational potential energy to kinetic energy of the stone
C kinetic energy to gravitational potential energy of the stone
D kinetic energy of the stone to thermal energy

6. June/2021/Paper_12/No.16

An object of weight 12 N rests on a platform on top of a container with two pistons, as shown. The container contains a fixed mass of gas, and the pistons are free to move.



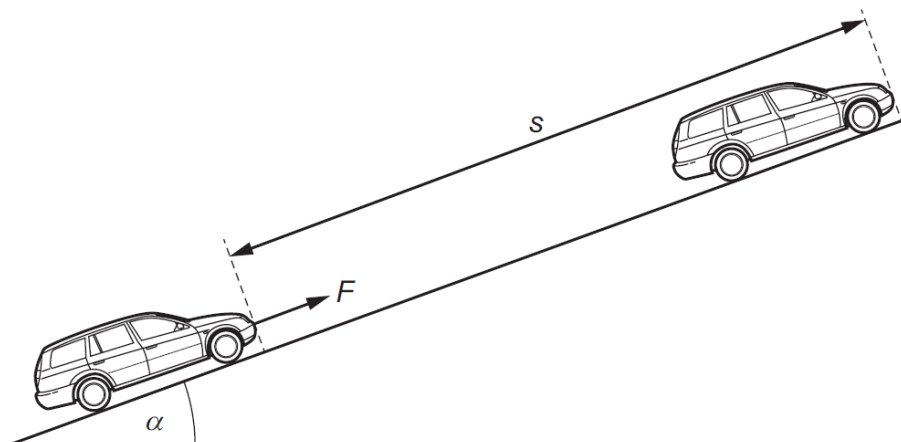
The plunger is slowly pushed 4.0 cm to the right. As a result, the object slowly moves upwards a distance 0.50 cm.

How much work is done on the object?

- A 0.060 J B 0.48 J C 6.0 J D 48 J

7. June/2021/Paper_12/No.17

A constant force F , acting on a car of mass m , moves the car up a slope through a distance s at constant velocity v . The angle of the slope to the horizontal is α .



The acceleration of free fall is g .

What is the ratio $\frac{\text{gravitational potential energy gained by car}}{\text{work done by force } F}$?

- A $\frac{mgs \sin \alpha}{Fv}$ B $\frac{mv}{Fs}$ C $\frac{mv^2}{2Fs}$ D $\frac{mg \sin \alpha}{F}$

8. June/2021/Paper_12/No.18

What is the definition of power?

- A Power is the product of force and velocity.
- B Power is the product of force and work done per unit time.
- C Power is the product of force per unit time and velocity.
- D Power is the rate at which work is done.

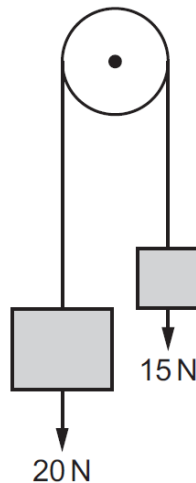
9. Nov/2021/Paper_11/No.15

Which statement about energy is **not** correct?

- A Energy is never lost but it may be transferred between different forms.
- B In an inelastic collision, the total energy is constant.
- C The efficiency of a system is the ratio of the useful energy output to the total energy input.
- D When a machine does work, friction reduces the total energy.

10. Nov/2021/Paper_11/No.16

A pulley of radius 0.40 m supports weights of 20 N and 15 N by means of a thin string, as shown.



The weights are moved by slowly rotating the pulley clockwise through an angle of 60° .

What is the increase in the total gravitational potential energy of the weights?

- A 0.33 J B 2.0 J C 2.1 J D 15 J

11. Nov/2021/Paper_11/No.17

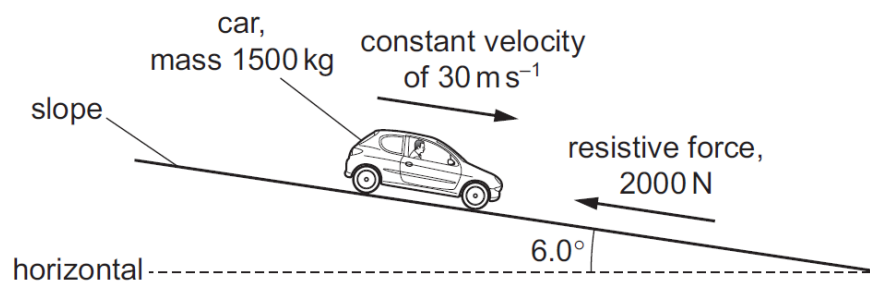
A car of mass 1500 kg accelerates from an initial speed of 15 m s^{-1} . This acceleration causes the car to gain $3.0 \times 10^5 \text{ J}$ of kinetic energy.

What is the change in the speed of the car?

- A 5.4 m s^{-1} B 10 m s^{-1} C 20 m s^{-1} D 25 m s^{-1}

12. Nov/2021/Paper_11/No.18

A car of mass 1500 kg travels at a constant velocity of 30 m s^{-1} down a slope. The slope is at an angle of 6.0° to the horizontal, as shown.



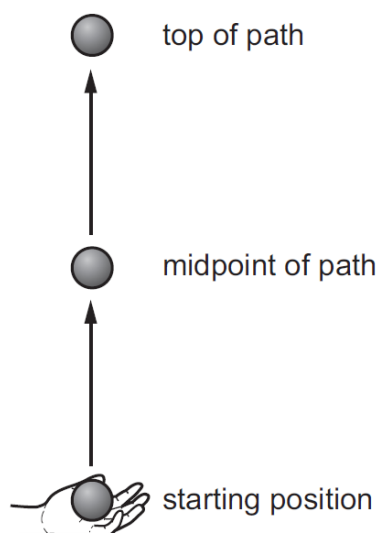
The magnitude of the total resistive force acting on the car is 2000 N.

What is the power output of the car's engine?

- A 14 kW B 60 kW C 110 kW D 380 kW

13. Nov/2021/Paper_12/No.16

A ball is thrown vertically upwards into the air. It rises to the top of its path before beginning to fall vertically downwards.



Assume that the gravitational potential energy of the ball is zero at its starting position.

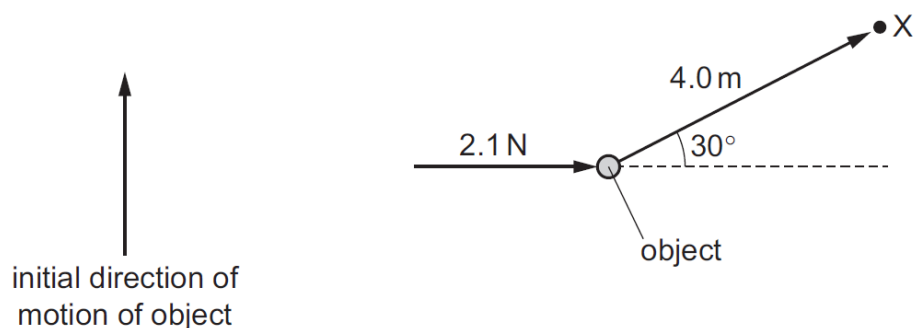
Which statement about the ball is **not** correct?

- A As it rises, its kinetic energy is transferred to gravitational potential energy.
- B At the midpoint of its path, its gravitational potential energy is equal to its initial kinetic energy.
- C At the top of its path, its kinetic energy is zero.
- D At the top of its path, its total energy is less than its initial total energy.

14. Nov/2021/Paper_12/No.17

An object slides with constant velocity across a horizontal sheet of ice. Friction is negligible.

A constant horizontal force of 2.1 N is then applied to the object as shown.



A short time after applying the force, the object reaches point X at a displacement of 4.0 m from its position when the force was first applied.

What is the work done by the force on the object as it travels to point X?

- A 4.2 J B 4.8 J C 7.3 J D 8.4 J

15. Nov/2021/Paper_12/No.18

The energy conversions inside a power station burning fossil fuel can be simplified as shown.

chemical energy $W \rightarrow$ thermal energy $X \rightarrow$ electrical energy Y

Which expression gives the efficiency of the power station?

- A $\frac{Y}{W}$ B $\frac{Y}{(W + X)}$ C $\frac{Y}{X}$ D $\frac{Y}{(W + X + Y)}$

16. Nov/2021/Paper_12/No.19

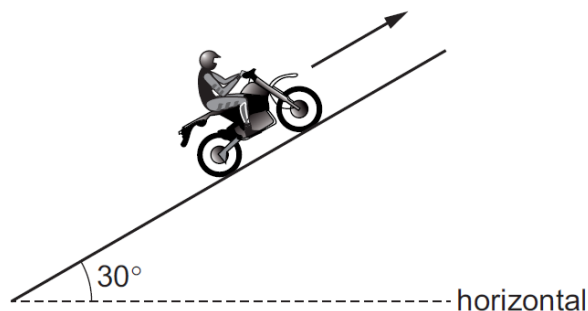
Car X is travelling at half the speed of car Y. Car X has twice the mass of car Y.

Which statement is correct?

- A Car X has half the kinetic energy of car Y.
B Car X has one quarter of the kinetic energy of car Y.
C Car X has twice the kinetic energy of car Y.
D The two cars have the same kinetic energy.

17. Nov/2021/Paper_12/No.20

The total weight of a motorbike and rider is 1800 N. The motorbike travels in a straight line at constant speed up a hill at an angle of 30° to the horizontal.



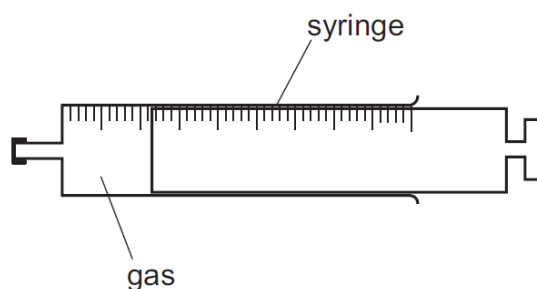
The useful output power of the motorbike is 36 000 W. The total resistive force due to air resistance and friction on the motorbike and rider is 2400 N.

What is the speed of the motorbike?

- A 8.6 ms^{-1} B 11 ms^{-1} C 15 ms^{-1} D 24 ms^{-1}

18. Nov/2021/Paper_13/No.16

A gas is contained inside a syringe, as shown.



The initial volume of the gas is 2.00 cm^3 .

Atmospheric pressure is 101 kPa.

What is the work done by the gas on the atmosphere when the gas is heated and expands to a volume of 6.00 cm^3 ?

- A $404 \text{ }\mu\text{J}$ B 404 mJ C 404 J D 404 kJ

19. Nov/2021/Paper_13/No.17

A mechanical device does useful work at rate X and wastes energy at rate Y .

Which expression gives the efficiency of this device?

- A $\frac{X}{Y}$ B $\frac{(X - Y)}{Y}$ C $\frac{X}{(X + Y)}$ D $\frac{(X - Y)}{(X + Y)}$

20. Nov/2021/Paper_13/No.18

Car P has kinetic energy 240 kJ.

Car Q has half the mass and twice the speed of car P.

What is the kinetic energy of car Q?

- A** 120 kJ **B** 240 kJ **C** 480 kJ **D** 960 kJ

21. Nov/2021/Paper_13/No.19

A water pump is driven by an engine. The pump raises a volume of 0.50 m^3 of water in 1.0 minute from a depth of 30 m. The pump has an efficiency of 70%.

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

What is the useful output power from the engine?

- A** 2.5 kW **B** 3.5 kW **C** 150 kW **D** 210 kW

1. Nov/2021/Paper_22/No.3

(a) Define *power*.

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

(b) A car of mass 1700 kg moves in a straight line along a slope that is at an angle θ to the horizontal, as shown in Fig. 3.1.

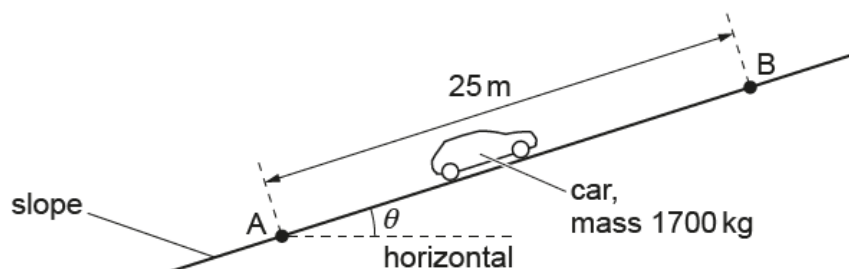


Fig. 3.1 (not to scale)

The car moves at constant velocity for a distance of 25 m from point A to point B.
Air resistance and friction provide a total resistive force of 440 N that opposes the motion of the car.

For the movement of the car from A to B:

(i) state the change in the kinetic energy

change in kinetic energy = ... J [1]

(ii) calculate the work done against the total resistive force.

work done = ... J [1]

- (c) The movement of the car in (b) from A to B causes its gravitational potential energy to increase by $4.8 \times 10^4 \text{ J}$.

Calculate:

- (i) the increase in vertical height h of the car for its movement from A to B

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

- (ii) angle θ .

$$\theta = \dots\dots\dots^\circ \text{ [1]}$$

- (d) The engine of the car in (b) produces an output power of $1.7 \times 10^4 \text{ W}$ to move the car along the slope.

Calculate the time taken for the car to move from A to B.

$$\text{time} = \dots\dots\dots \text{ s [2]}$$

[Total: 8]

A person uses a trolley to move suitcases at an airport. The total mass of the trolley and suitcases is 72 kg.

- (a) The person pushes the trolley and suitcases along a horizontal surface with a constant speed of 1.4 ms^{-1} and then releases the trolley. The released trolley moves in a straight line and comes to rest. Assume that a constant total resistive force of 18 N opposes the motion of the trolley and suitcases.

- (i) Calculate the power required to overcome the total resistive force on the trolley and suitcases when they move with a constant speed of 1.4 ms^{-1} .

power = ... W [2]

- (ii) Calculate the time taken for the trolley to come to rest after it is released.

time = ... s [3]

- (b) At another place in the airport, the trolley and suitcases are on a slope, as shown in Fig. 2.1.

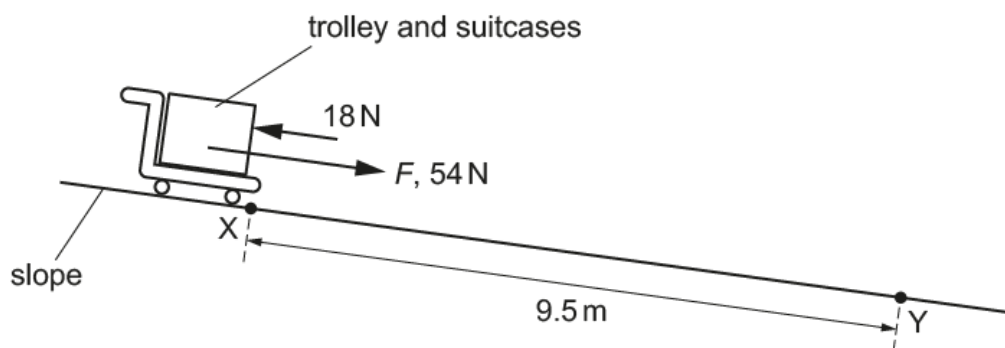


Fig. 2.1 (not to scale)

The person releases the trolley from rest at point X. The trolley moves down the slope in a straight line towards point Y. The distance along the slope between points X and Y is 9.5 m.

The component F of the weight of the trolley and suitcases that acts along the slope is 54 N. Assume that a constant total resistive force of 18 N opposes the motion of the trolley and suitcases.

- (i) Calculate the speed of the trolley at point Y.

speed = ... ms^{-1} [3]

- (ii) Calculate the work done by F for the movement of the trolley from X to Y.

work done = ... J [1]

- (iii) The trolley is released at point X at time $t = 0$.

On Fig. 2.2, sketch a graph to show the variation with time t of the work done by F for the movement of the trolley from X to Y.

Numerical values of the work done and t are not required.

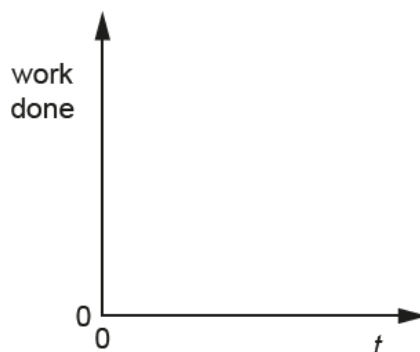


Fig. 2.2

[2]

- (c) The angle of the slope in (b) is constant. The frictional forces acting on the wheels of the moving trolley are also constant.

Explain why, in practice, it is incorrect to assume that the total resistive force opposing the motion of the trolley and suitcases is constant as the trolley moves between X and Y.

.....
 [1]

[Total: 12]

3. June/2021/Paper_22/No.3

A child of weight 330 N is at point X at the top of a slide. The slide is at the edge of a swimming pool, as shown in Fig. 3.1.

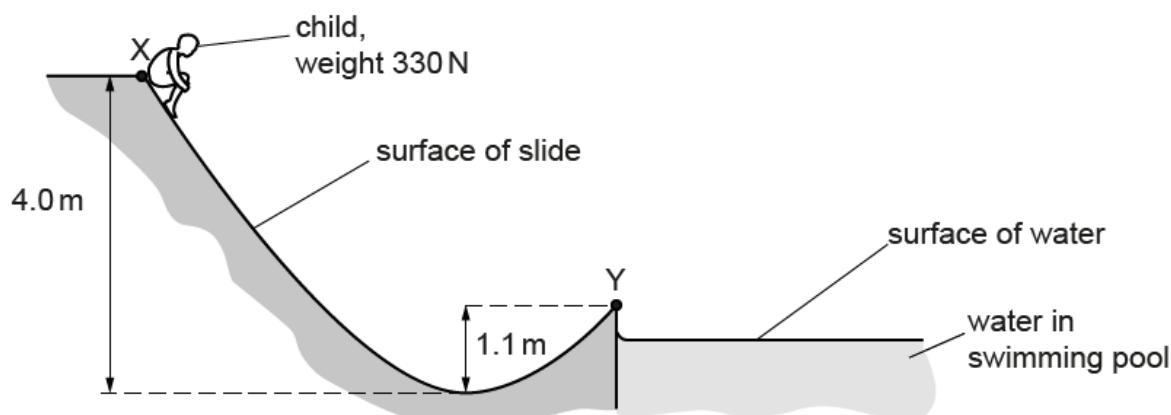


Fig. 3.1 (not to scale)

The child moves from rest to the lowest point of the slide that is a vertical distance of 4.0 m below X. The child continues moving towards point Y which is at the end of the slide and a vertical distance of 1.1 m above the lowest point. The kinetic energy of the child at Y is 540 J.

- (a) Calculate the difference in the gravitational potential energy of the child at points X and Y.

difference in gravitational potential energy = ... J [2]

- (b) An average frictional force of 52 N acts on the child when moving from X to Y.

By considering changes of energy, determine the distance moved by the child from X to Y.

distance moved = ... m [2]

- (c) The child leaves the slide at point Y with a velocity that is at an angle of 41° to the horizontal. The path of the child through the air is shown in Fig. 3.2.

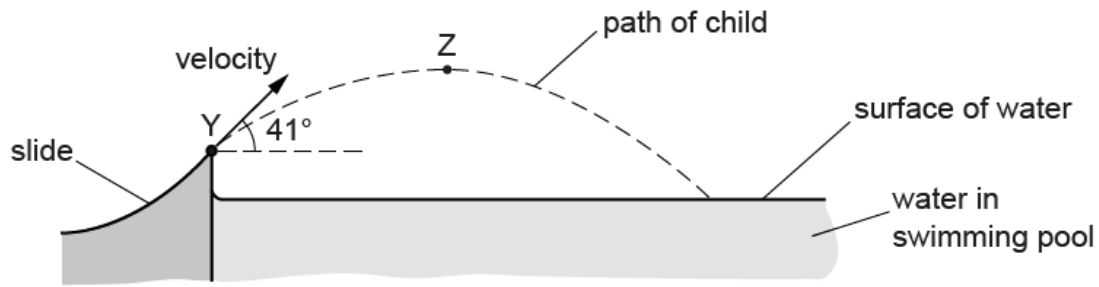


Fig. 3.2 (not to scale)

Point Z is the highest point on the path of the child through the air. Assume that air resistance is negligible.

Calculate the speed of the child at:

- (i) point Y

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

- (ii) point Z.

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

[Total: 8]

(a) State what is meant by *work done*.

.....
 [1]

(b) A beach ball is released from a balcony at the top of a tall building. The ball falls vertically from rest and reaches a constant (terminal) velocity. The gravitational potential energy of the ball decreases by 60 J as it falls from the balcony to the ground. The ball hits the ground with speed 16 m s^{-1} and kinetic energy 23 J.

(i) Show that the mass of the ball is 0.18 kg.

[2]

(ii) Calculate the height of the balcony above the ground.

height = ... m [2]

(iii) Determine the average resistive force acting on the ball as it falls from the balcony to the ground.

average resistive force = ... N [2]

- (c) State and explain the variation, if any, in the magnitude of the acceleration of the ball in (b) during the time interval when the ball is moving downwards **before** it reaches constant (terminal) velocity.

.....

.....

.....

.....

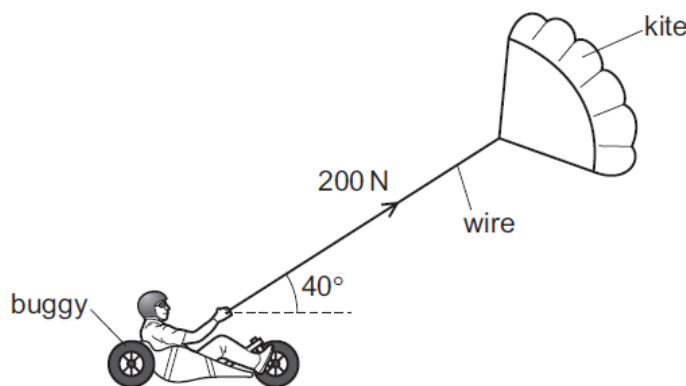
.....

..... [3]

[Total: 10]

1. June/2023/Paper_ 9702/11/No.16

A man sits on a buggy that is pulled along by a wire attached to a kite. The wire is at an angle of 40° to the horizontal and has a constant tension of 200 N. The man and buggy travel a distance of 20 m along a straight horizontal path. The wire and the path of the buggy are in the same vertical plane.



What is the work done by the tension force on the man and buggy?

- A** 2.6 kJ **B** 3.1 kJ **C** 3.4 kJ **D** 4.0 kJ

2. June/2023/Paper_ 9702/11/No.17

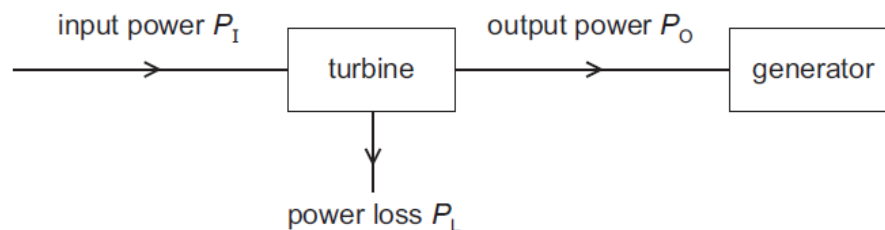
A ball is thrown vertically upwards from the surface of the Earth.

Which statement describes the energy of the ball as it rises through the air?

- A** The kinetic energy of the ball decreases as the gravitational potential energy decreases.
B The kinetic energy of the ball decreases as the gravitational potential energy increases.
C The kinetic energy of the ball increases as the gravitational potential energy decreases.
D The total energy of the ball increases.

3. June/2023/Paper_ 9702/12/No.15

A steam turbine is used to drive a generator. The input power to the turbine is P_I and the output power is P_O . The power loss in the turbine is P_L , as shown.



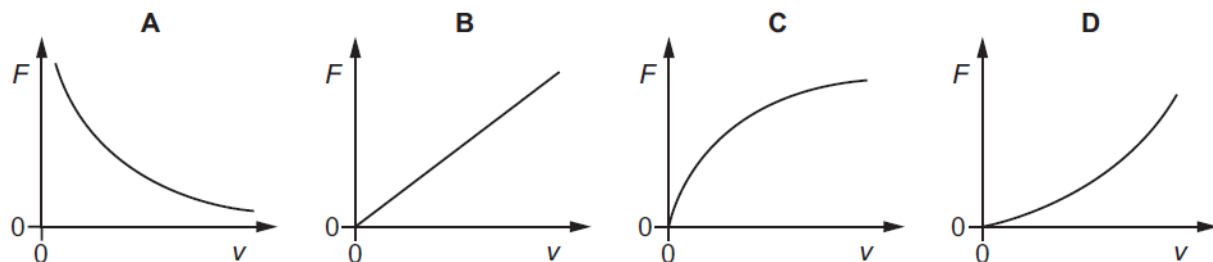
What is the efficiency of the turbine?

- A** $\frac{P_L}{P_O}$ **B** $\frac{P_I}{P_O}$ **C** $\frac{P_L}{P_I}$ **D** $\frac{P_O}{P_I}$

4. June/2023/Paper_ 9702/12/No.16

A variable force is applied to ensure that a constant power is supplied to a train.

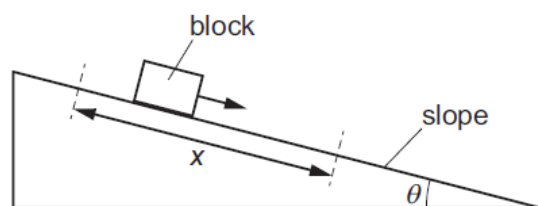
Which graph best shows the variation of the force F applied with the velocity v of the train?



5. June/2023/Paper_ 9702/12/No.17

A block is released from rest and slides a distance x down a straight slope.

The slope is at an angle θ to the horizontal.



The slope is frictionless and air resistance is negligible.

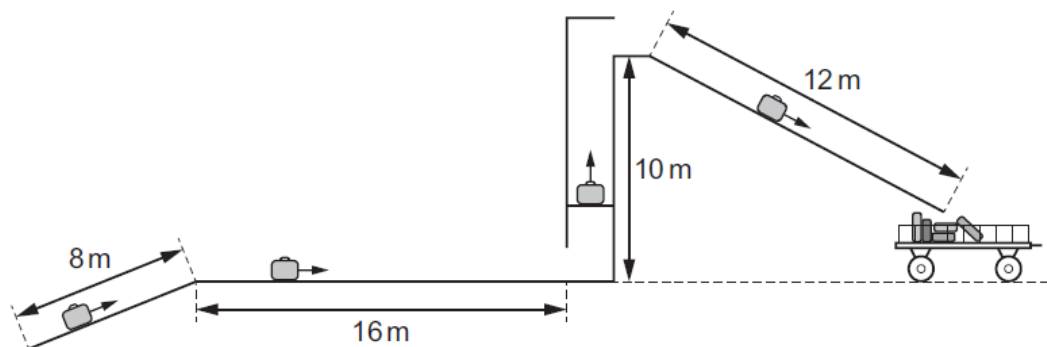
The acceleration of free fall is g .

Which expression gives the final speed of the block?

- A $\sqrt{\frac{gx \sin \theta}{2}}$ B $\sqrt{2gx \sin \theta}$ C $\sqrt{2gx}$ D $2gx \sin \theta$

6. June/2023/Paper_ 9702/13/No.15

An airport has a mechanical system for moving luggage. The system uses a horizontal conveyor belt, a sloping conveyor belt, a lift and a frictionless slide. A suitcase is moved around the airport using this system.



Resistive forces opposing the motion of the suitcase are negligible.

For which movement of the suitcase is the net work done on the suitcase greatest?

- A moving the suitcase a distance of 8 m at a constant speed up the sloping conveyor belt
- B moving the suitcase a distance of 16 m at a constant speed along the horizontal conveyor belt
- C moving the suitcase a distance of 10 m at a constant speed vertically upwards on the lift
- D moving the suitcase a distance of 12 m at increasing speed downwards on the slide

7. June/2023/Paper_ 9702/13/No.16

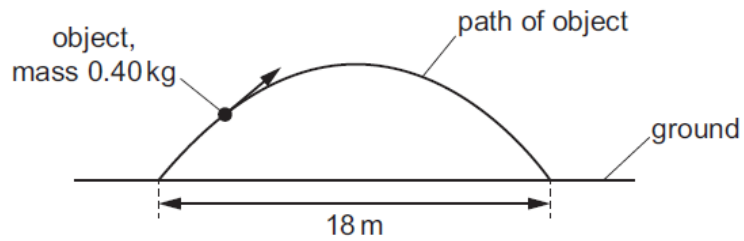
A car moves along a horizontal road with a constant velocity v against a resistive force F .

The engine of the car has an efficiency of 25%.

What is the input power to the engine?

- A $\frac{Fv}{4.0}$
- B $\frac{4.0}{Fv}$
- C $4.0Fv$
- D $\frac{4.0F}{v}$

An object of mass 0.40 kg is projected into the air and follows a curved path above horizontal ground.



The object takes a time of 1.5 s to move along its path. The object lands a horizontal distance of 18 m from its initial position. Air resistance is negligible.

What is the kinetic energy of the object at its maximum height?

- A** 0 J **B** 2.4 J **C** 11 J **D** 29 J

- (c) The string is cut so that the spring extends upwards. This causes the beam to rotate and launch the block into the air. The block reaches its maximum height and then falls back to the ground.

Fig. 2.2 shows part of the path of the block in the air shortly before it hits the horizontal ground.

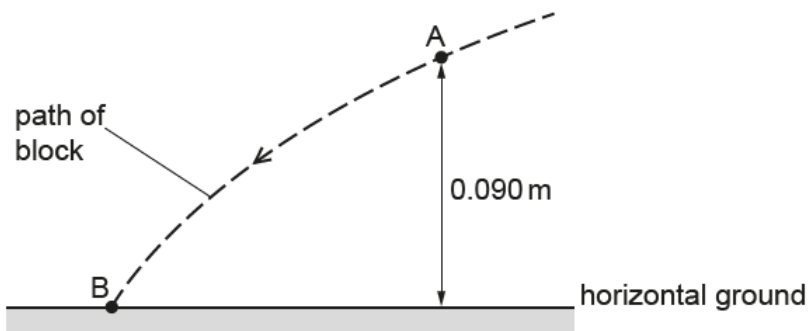


Fig. 2.2 (not to scale)

The block is at a height of 0.090 m above the ground when it passes through point A. The block has a kinetic energy of 0.044 J when it hits the ground at point B.

Air resistance is negligible.

- (i) Calculate the decrease in the gravitational potential energy of the block for its movement from A to B.

decrease in gravitational potential energy = ... J [2]

- (ii) Use your answer in (c)(i) and conservation of energy to determine the speed of the block at point A.

speed = ... ms^{-1} [3]

- (iii) By reference to the force on the block, explain why the horizontal component of the velocity of the block remains constant as it moves from A to B.

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

- (iv) The block passes through point A at time t_A and arrives at point B at time t_B .

On Fig. 2.3, sketch a graph to show the variation of the magnitude of the vertical component v_y of the velocity of the block with time t from $t = t_A$ to $t = t_B$. Numerical values of v_y are not required.

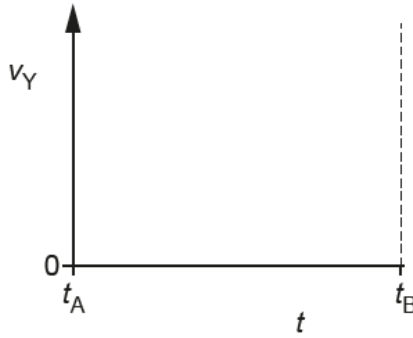


Fig. 2.3

[1]

- (c) The beam in (b) rotates when the string is cut and the small block of weight 2.4 N is projected through the air. Fig. 2.2 shows the last part of the path of the block before it hits the ground at point Y.

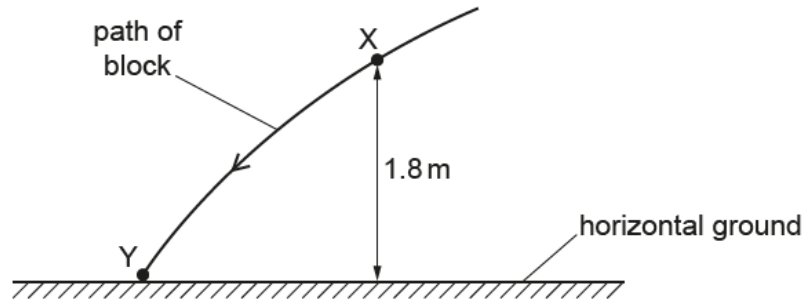


Fig. 2.2 (not to scale)

At point X on the path, the block has a speed of 3.4 m s^{-1} and is at a height of 1.8 m above the horizontal ground. Air resistance is negligible.

- (i) Calculate the decrease in the gravitational potential energy of the block for its movement from X to Y.

decrease in gravitational potential energy = ... J [2]

- (ii) Use your answer to (c)(i) and conservation of energy to determine the kinetic energy of the block at Y.

kinetic energy = ... J [3]

- (iii) State the variation, if any, in the direction of the acceleration of the block as it moves from X to Y.

..... [1]

- (iv) The block passes point X at time t_X and arrives at point Y at time t_Y .

On Fig. 2.3, sketch a graph to show the variation of the magnitude of the horizontal component of the velocity of the block with time from t_X to t_Y . Numerical values are not required.

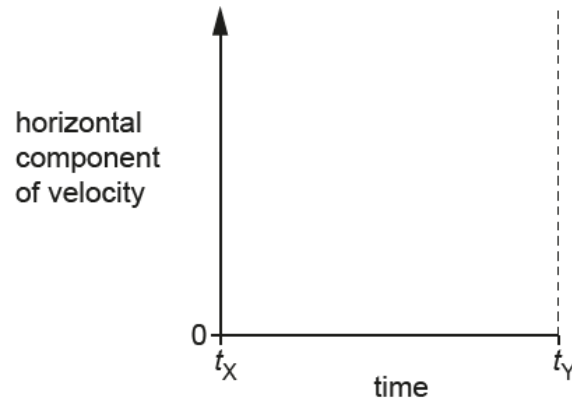


Fig. 2.3

[1]

11. March/2023/Paper_9702/12/No.16

A system with an efficiency of 74% wastes 230 W of power.

What is the useful output power of the system?

- A 170 W B 310 W C 650 W D 880 W

12. March/2023/Paper_9702/12/No.17

A projectile of mass 0.25 kg is at a height of 30 m above horizontal ground and travelling at a speed of 15 m s^{-1} . A short time later, it is at a height of 35 m above the horizontal ground and travelling at a speed of 5.0 m s^{-1} .

How much work is done against air resistance during this time?

- A 0 J B 13 J C 25 J D 37 J

13. March/2023/Paper_9702/22/No.2a(ii), (b)

A motor uses a wire to raise a block, as illustrated in Fig. 2.1.

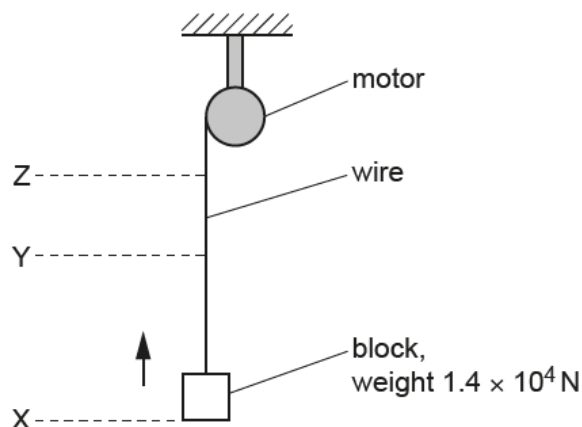


Fig. 2.1 (not to scale)

The base of the block takes a time of 0.49 s to move vertically upwards from level X to level Y at a constant speed of 0.64 m s^{-1} . During this time the wire has a strain of 0.0012. The wire is made of metal of Young modulus $2.2 \times 10^{11} \text{ Pa}$ and has a uniform cross-section.

The block has a weight of $1.4 \times 10^4 \text{ N}$. Assume that the weight of the wire is negligible.

- (ii) the increase in the gravitational potential energy of the block for the movement of its base from X to Y.

increase in gravitational potential energy = ... J [3]

- (b) The motor has an efficiency of 56%.

Calculate the input power to the motor as the base of the block moves from X to Y.

input power = ... W [3]

1. Nov/2023/Paper_ 9702/11/No.15

A crate of mass 50 kg is pushed a distance of 6.0 m along a horizontal surface against a constant resistive force of 70 N. The crate moves at a constant speed. It is then lifted, at a constant speed, through a vertical distance of 1.2 m onto the back of a lorry.

What is the total work done in this process?

- A 420 J B 480 J C 590 J D 1000 J

2. Nov/2023/Paper_ 9702/11/No.16

The input power to a television is P_{in} . The useful sound and light power emitted by the television is P_{out} .

What is the efficiency of the television?

- A $\frac{P_{\text{out}}}{P_{\text{in}}}$ B $\frac{P_{\text{in}} - P_{\text{out}}}{P_{\text{in}}}$ C $\frac{P_{\text{in}}}{P_{\text{out}}}$ D $\frac{P_{\text{out}}}{P_{\text{in}} - P_{\text{out}}}$

3. Nov/2023/Paper_ 9702/11/No.17

A builder holding a brick of mass 3000 g drops the brick on his foot.

What is a reasonable estimate of the change in gravitational potential energy of the brick?

- A 30 J B 300 J C 3000 J D 30 000 J

4. Nov/2023/Paper_ 9702/12/No.15

An electric car travels at a constant speed of 70 km h^{-1} for 80 km on a straight horizontal road and uses energy E from its battery.

The total resistive force acting on the car is proportional to $(\text{speed})^2$. Assume that the electric motor is 100% efficient.

How much energy is used from the battery when the car travels at a constant speed of 60 km h^{-1} for 80 km on the straight horizontal road?

- A $0.73E$ B $0.86E$ C $1.2E$ D $1.4E$

5. Nov/2023/Paper_ 9702/12/No.16

What is meant by the efficiency of a system?

- A the total energy input to the system divided by the useful energy output by the system
B the useful energy output from the system divided by the energy wasted by the system
C the useful energy output from the system divided by the total energy input to the system
D the energy wasted by the system divided by the total energy input to the system

6. Nov/2023/Paper_ 9702/12/No.17

When an object of mass m is raised through a vertical height Δh , the gain of its gravitational potential energy is ΔE_p .

ΔE_p and Δh are related by the equation

$$\Delta E_p = mg\Delta h,$$

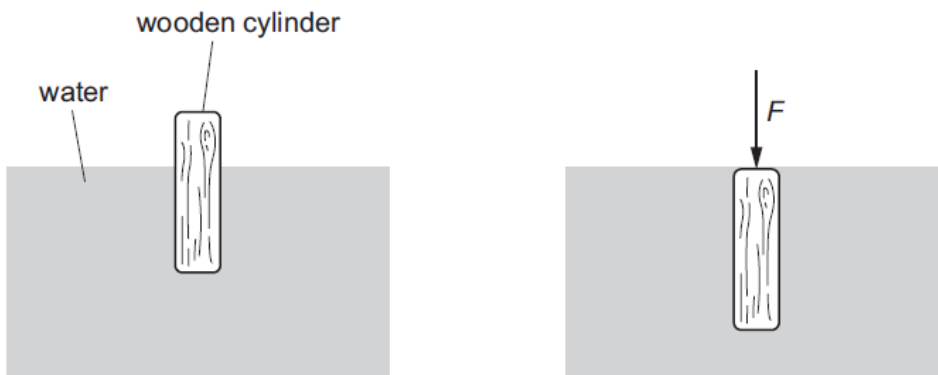
where g is the acceleration of free fall.

The definition of which physical quantity is needed to derive this equation?

- A acceleration
- B momentum
- C power
- D work done

7. Nov/2023/Paper_ 9702/13/No.15

A wooden cylinder floats partially submerged in a bath of water. A force F is applied to the cylinder until it is just fully submerged.



Which statement is **not** correct?

- A Some of the water gains gravitational potential energy.
- B The cylinder loses gravitational potential energy.
- C Work is done by force F on the cylinder.
- D Work is done by the upthrust on the cylinder.

8. Nov/2023/Paper_ 9702/13/No.16

A system has a useful power output of 4.0 W and a wasted power of 16 W.

What is the efficiency of the system?

- A 5.0% B 20% C 25% D 80%

9. Nov/2023/Paper_ 9702/13/No.17

A parachutist is falling towards the ground at a constant speed v . The rate at which she is losing gravitational potential energy is R .

The acceleration of free fall is g .

What is the mass of the parachutist?

- A $\frac{gv}{R}$ B $\frac{R}{gv}$ C $\frac{2R}{v^2}$ D $\frac{v^2}{2R}$