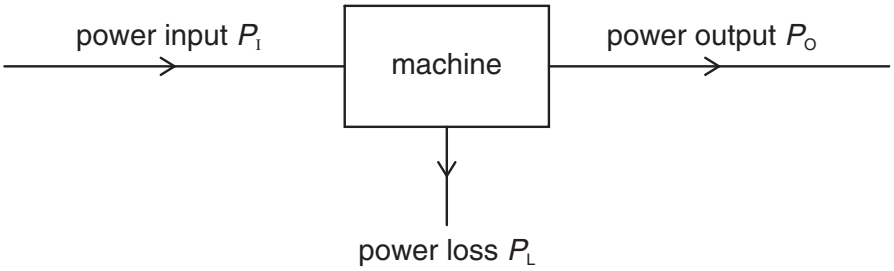
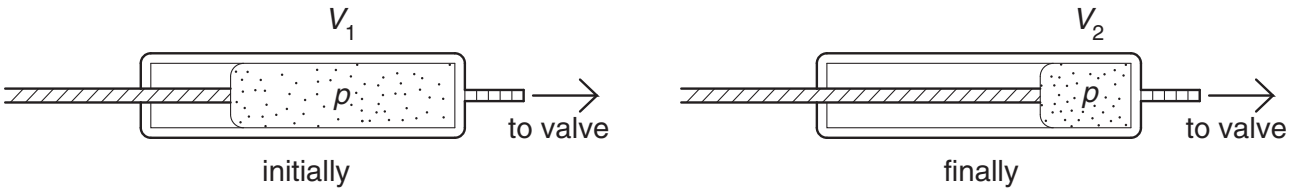
16 Power is transferred through a machine as shown. 9702/1/M/J/02



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. 9702/1/M/J/02

At what speed does it travel?

A 2.5 m s^{-1}

B 4.0 m s^{-1}

C 25 m s^{-1}

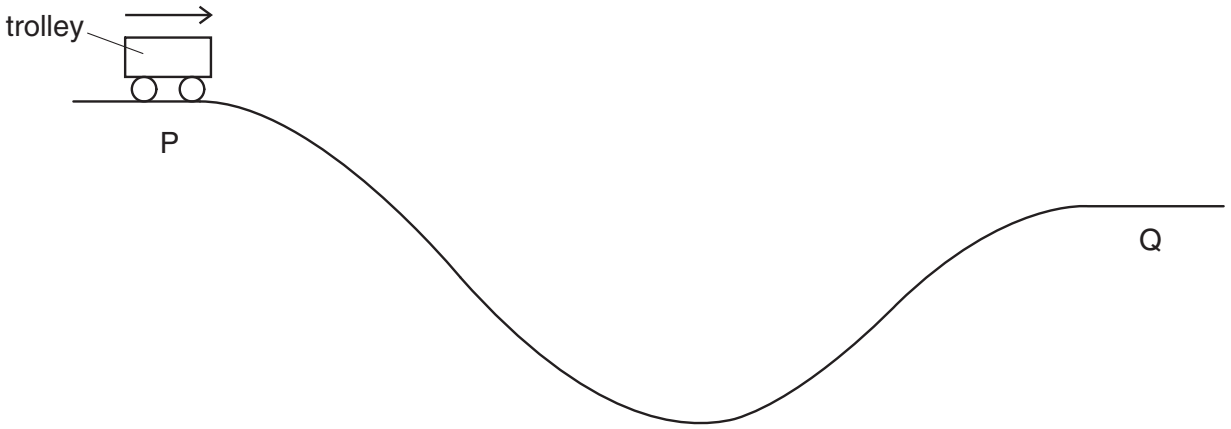
D 40 m s^{-1}

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/O/N/02

What is the minimum pump output power required to deal with 1.3×10^9 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

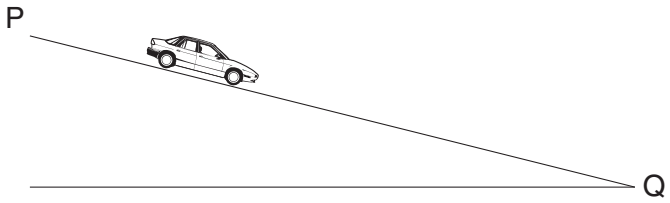
A energy x time

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

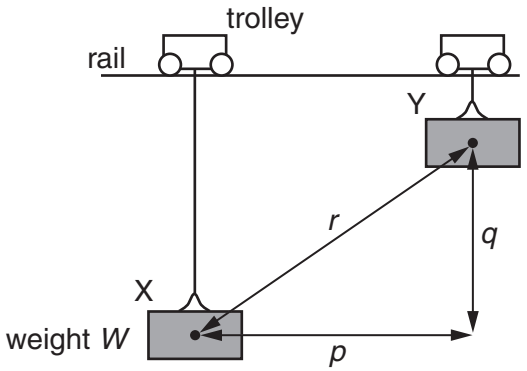
A force x distance moved in the direction of the force

B force x velocity

C work done ÷ 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?

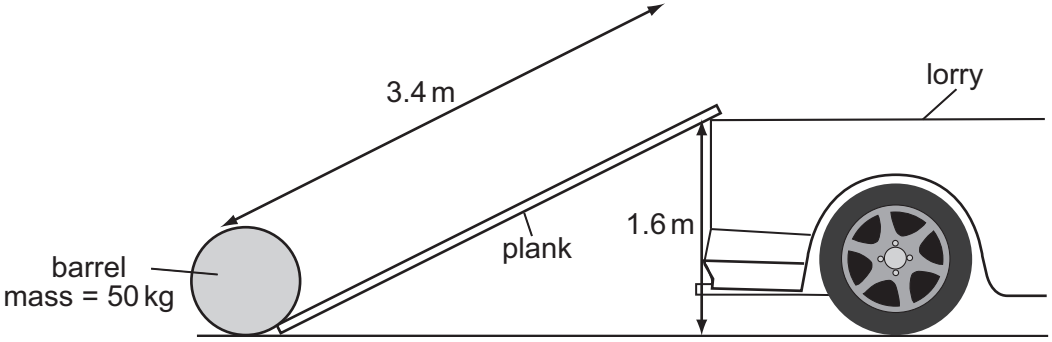
A Car X has half the kinetic energy of car Y.

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

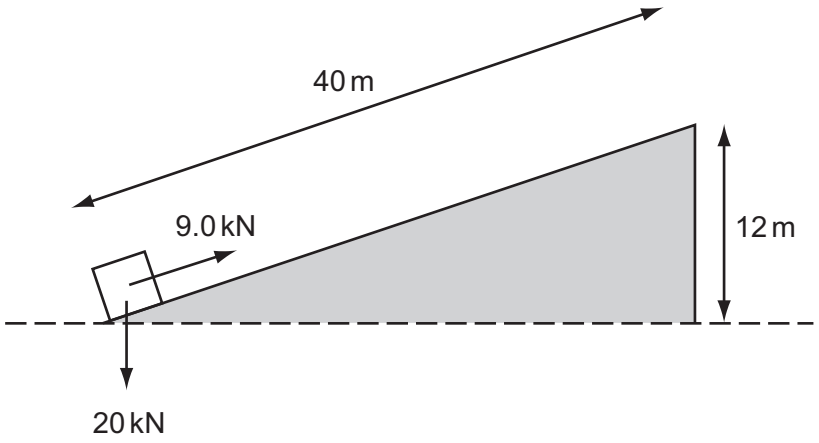
17 A cyclist is capable of generating an average power of 3.0 kW during a 4.0 km speed trial. His aerodynamic suit and position on the cycle reduce resistive forces to 180 N. 9702/01/O/N/04

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

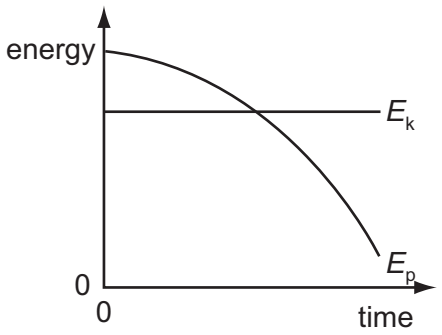
By what factor does its speed increase?

A 2 **B** 4 **C** 8 **D** 16

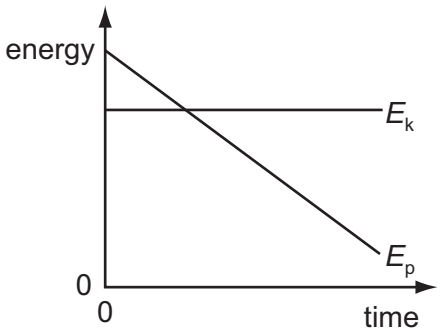
15 A steel ball is falling at constant speed in oil.

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

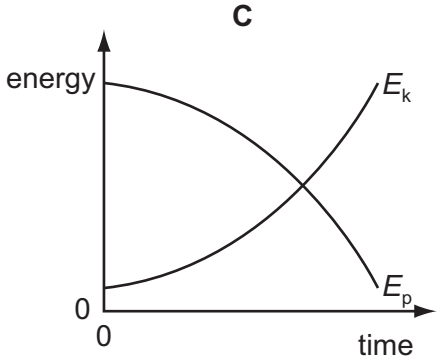
A



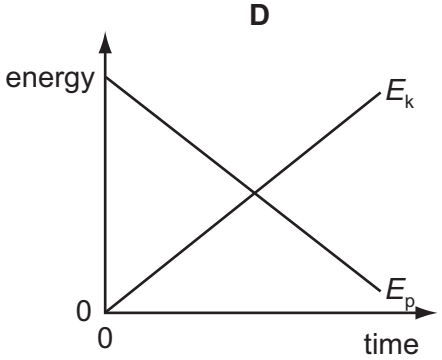
B



C



D



17 A concrete cube of side 0.50 m and uniform density 2.0×10^3 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

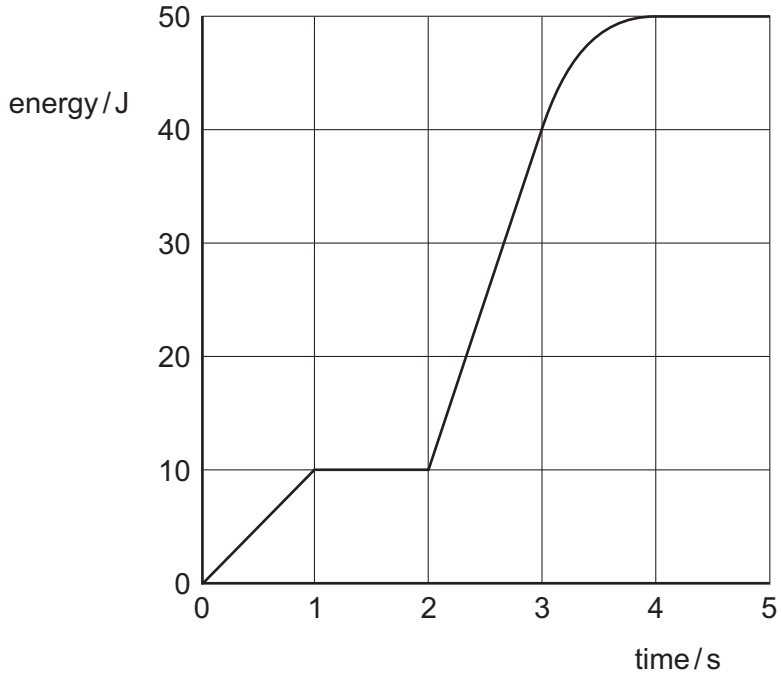
A It is the energy associated with the object's movement through space.

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?

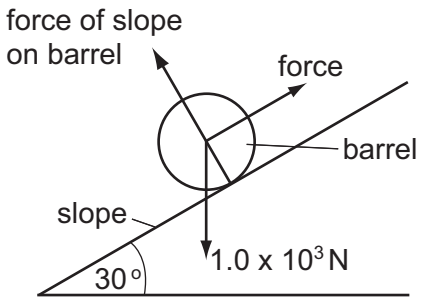
A 10 W **B** 13 W **C** 30 W **D** 50 W

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?

A 21 kJ **B** 42 kJ **C** 630 kJ **D** 1260 kJ

16 The diagram shows a barrel of weight 1.0 x 10^3 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?

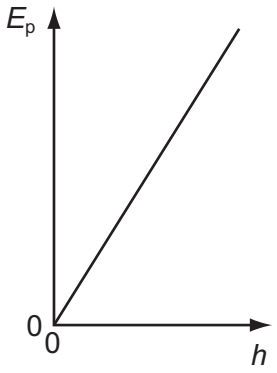
A 1.0 x 10^4 J **B** 2.5 x 10^3 J **C** 4.3 x 10^3 J **D** 5.0 x 10^3 J

15 An object is thrown into the air.

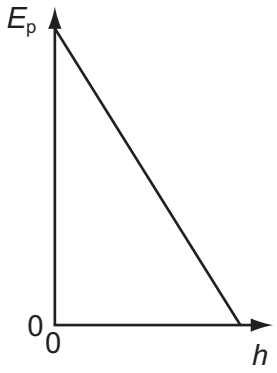
Which graph shows how the potential energy E_p of the object varies with height h above the ground?

9702/01/O/N/05

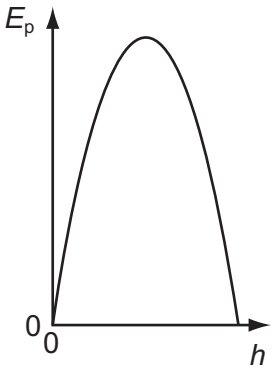
A



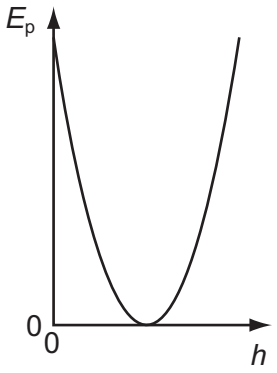
B



C



D



17 A motorist travelling at $10\,m\,s^{-1}$ can bring his car to rest in a braking distance of 10 m.

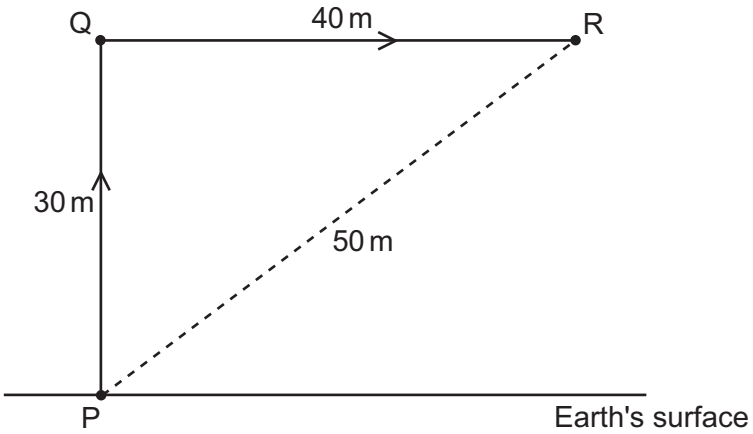
9702/01/M/J/06

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 × distance moved in the direction of the force

B force × velocity

C work done ÷ time taken

D work done × time taken

15 A car of mass 1000 kg first travels forwards at 25 m s^{-1} and then backwards at 5 m s^{-1}. 9702/01/O/N/07

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

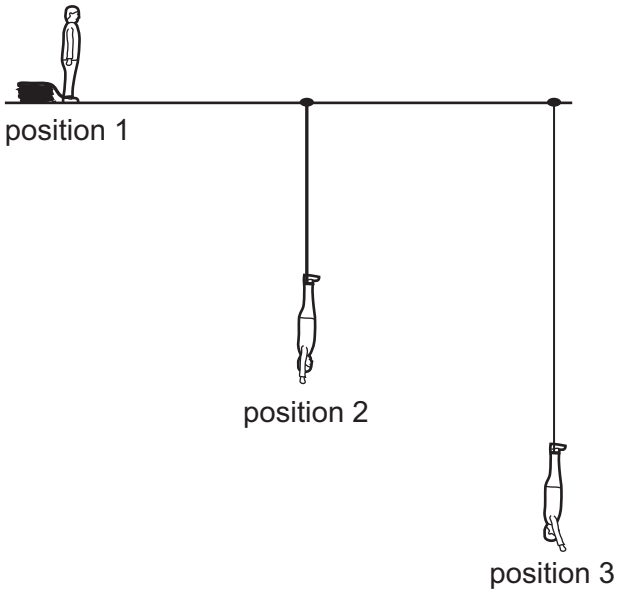
A 200 kJ **B** 300 kJ **C** 325 kJ **D** 450 kJ

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 $\frac{U}{W} \times 100\,\%$

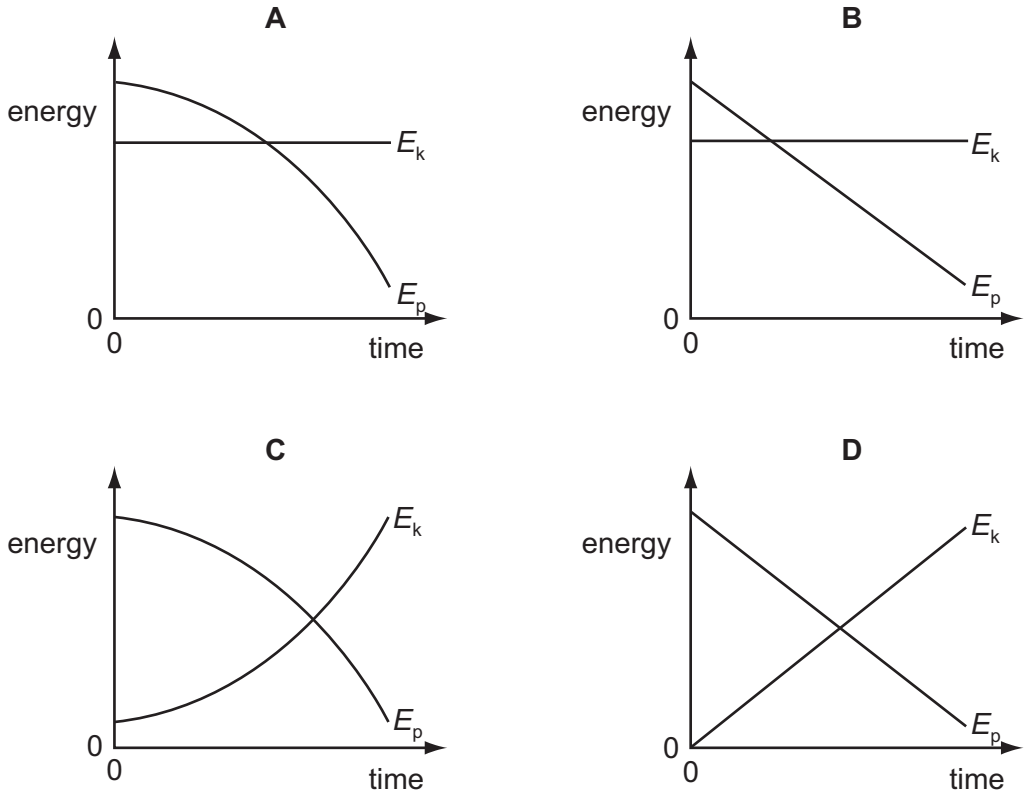
B $\frac{W}{E_{in}} \times 100\,\%$

C $\frac{U}{E_{in}} \times 100\,\%$

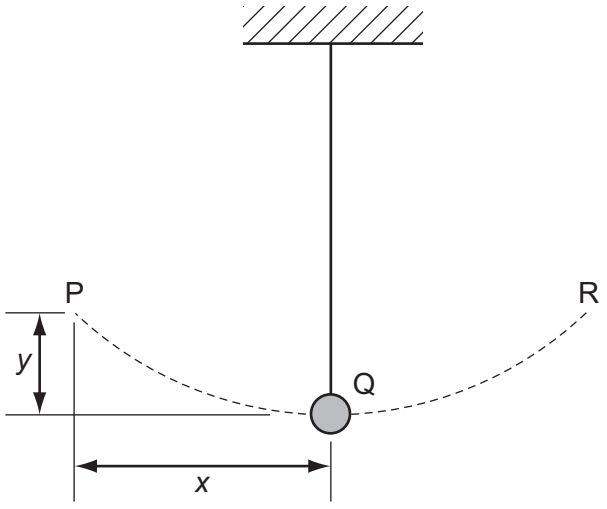
D $\frac{U+W}{E_{in}} \times 100\,\%$

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

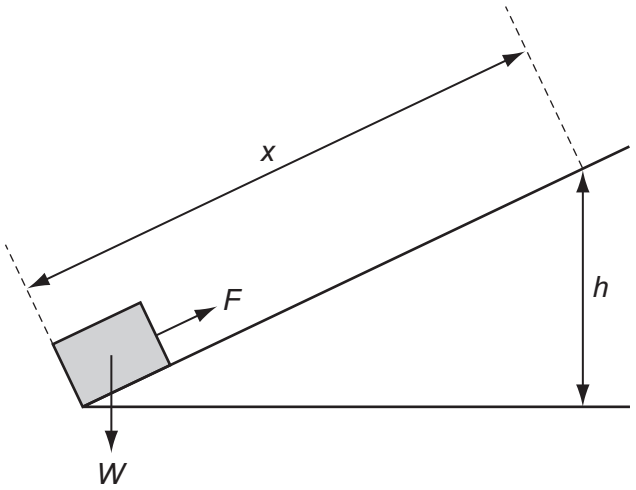


Assuming the gravitational potential energy lost in moving from P to Q is converted into kinetic energy, what is the speed of the bob at Q?

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.



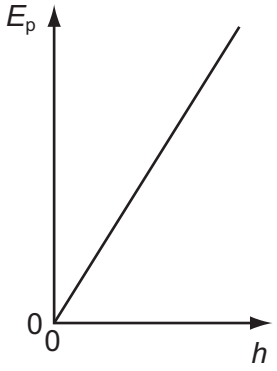
Which expressions give the amount of work done on the block and the amount of gravitational potential energy gained by the block?

	work done	gravitational potential energy
A	Fx	Wh
B	Fh	Wx
C	Wx	Fh
D	Wh	Fx

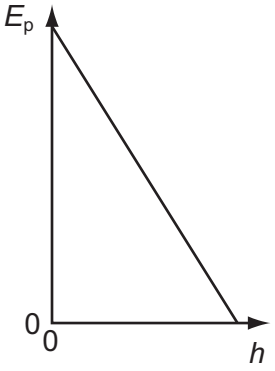
16 An object is thrown into the air. 9702/01/O/N/08

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

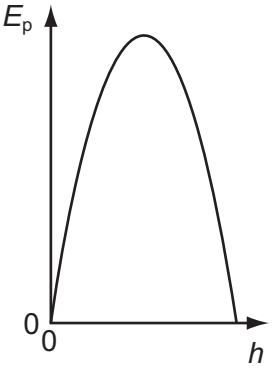
A



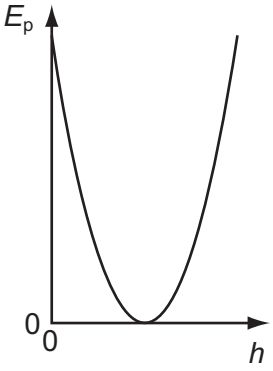
B



C



D



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

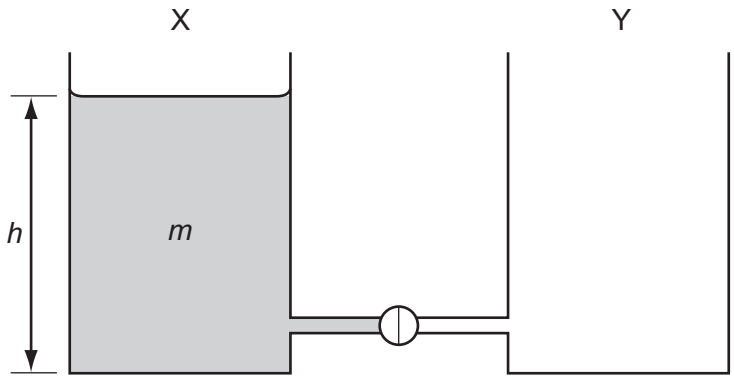
14 The forward motion of a motor-boat is opposed by forces F which vary with the boat's speed v in accordance with the relation $F = kv^2$, where k is a constant. 9702/01/M/J/09

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)

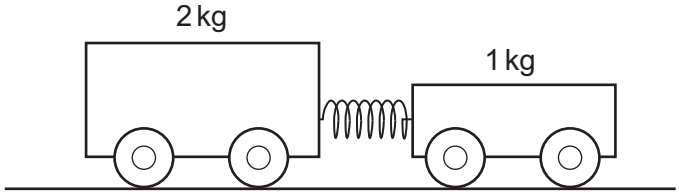
A 0 **B** $\frac{mgh}{4}$ **C** $\frac{mgh}{2}$ **D** mgh

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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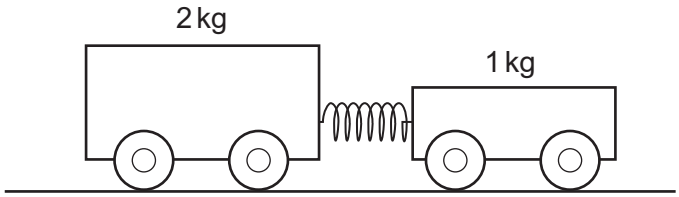
A 0.50 E **B** 0.71 E **C** 0.87 E **D** E

14 Two trolleys are placed together on a horizontal runway with a compressed spring between them. 9702/12/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

15 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 %. 9702/12/O/N/09

What is the current from the overhead wires when the locomotive is operating at its maximum power?

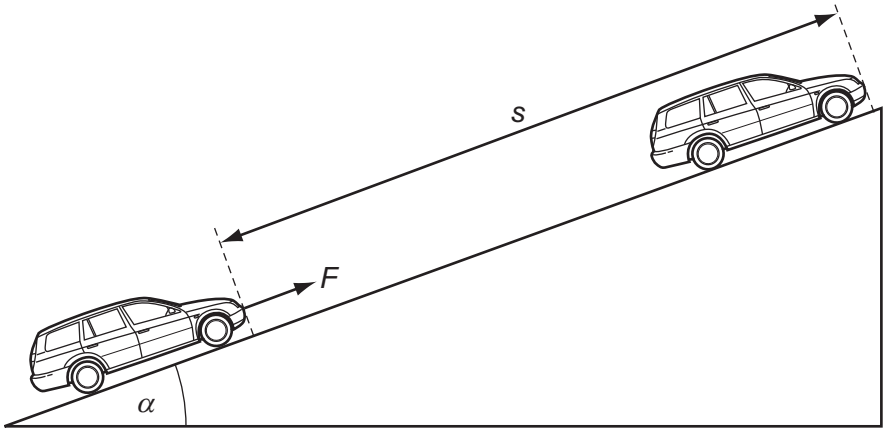
A 130 A **B** 160 A **C** 200 A **D** 250 A

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** $\frac{mg\sin\alpha}{F}$

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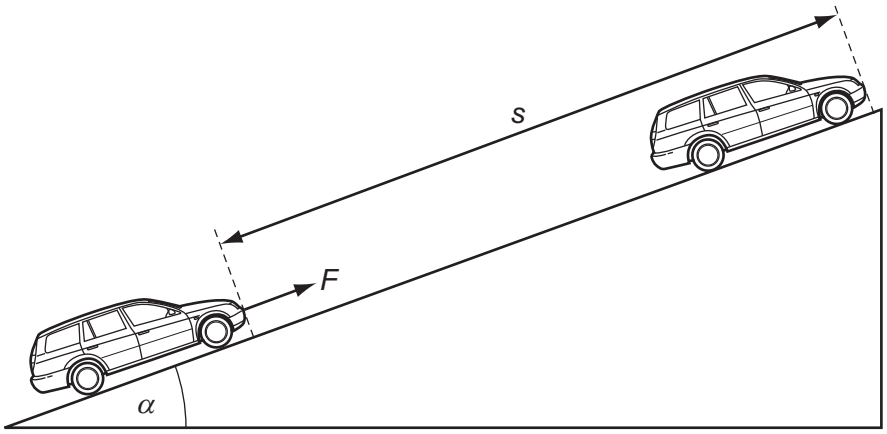

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16 What is the internal energy of a system? 9702/11/O/N/10

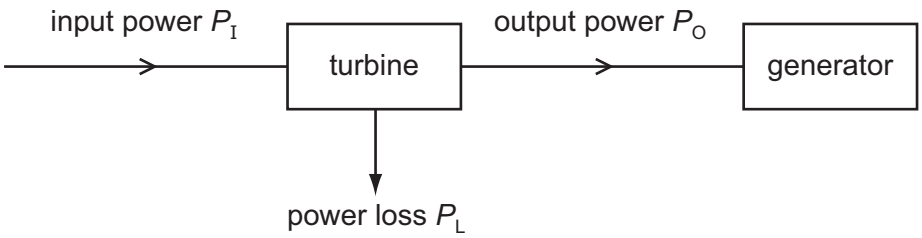
A the amount of heat supplied to the system

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



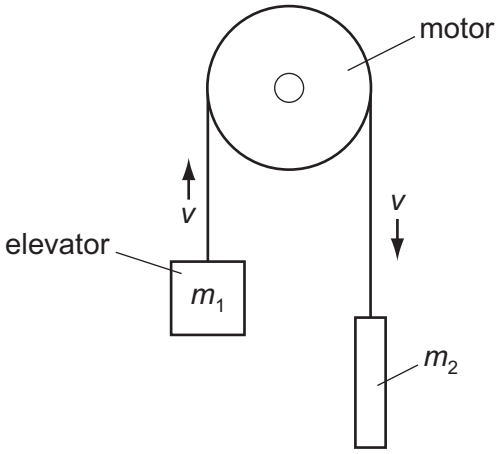
What is the efficiency of the turbine?

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	N m	J
B	J s^{-1}	J	J s^{-1}
C	N m	N m	W
D	N m	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)

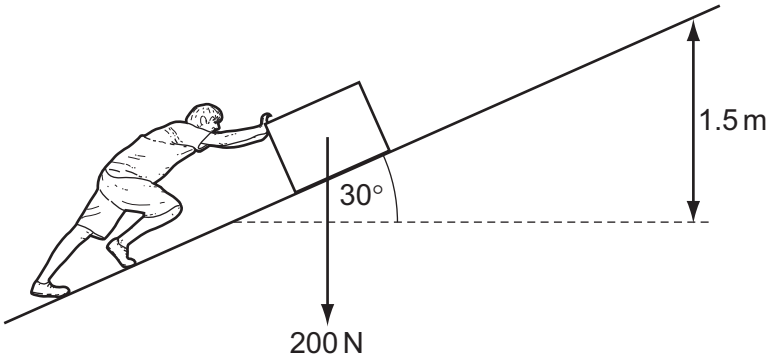
A $\frac{1}{2} m_1 v^2$

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** $\frac{m^3g^2}{2k^2}$

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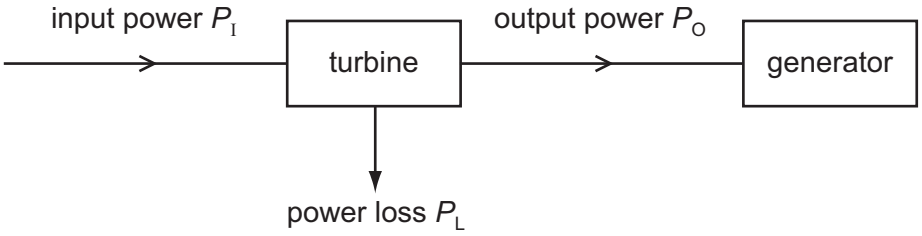

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18 What is the internal energy of a system? 9702/13/O/N/10

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

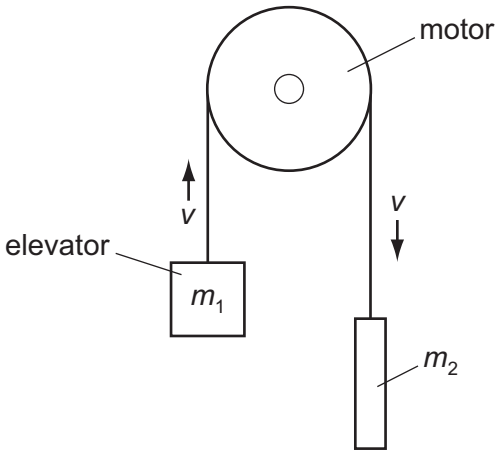
18 An electric motor produces 120 W of useful mechanical output power. The efficiency of the motor is 60 %. 9702/12/M/J/11

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).

9702/13/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 $\frac{1}{2} m_1 v^2$

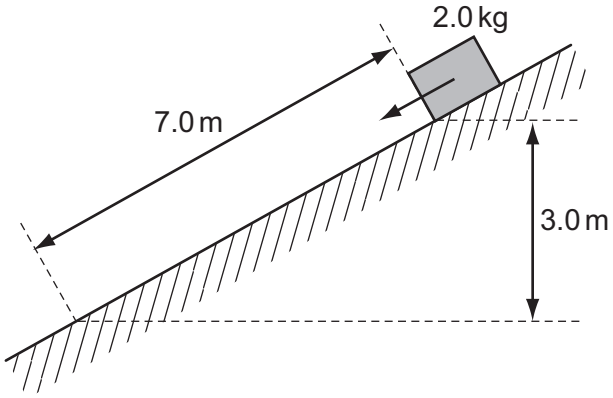
B $\frac{1}{2} (m_1 - m_2) v^2$

C $m_1 g v$

D $(m_1 - m_2) g v$

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 m s^{-1} **B** 6.6 m s^{-1} **C** 8.6 m s^{-1} **D** 10.1 m s^{-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** $1 - \frac{1}{\sqrt{2}}$

16 A body travelling with a speed of $10\,m\,s^{-1}$ has kinetic energy 1500 J. 9702/13/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

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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

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?

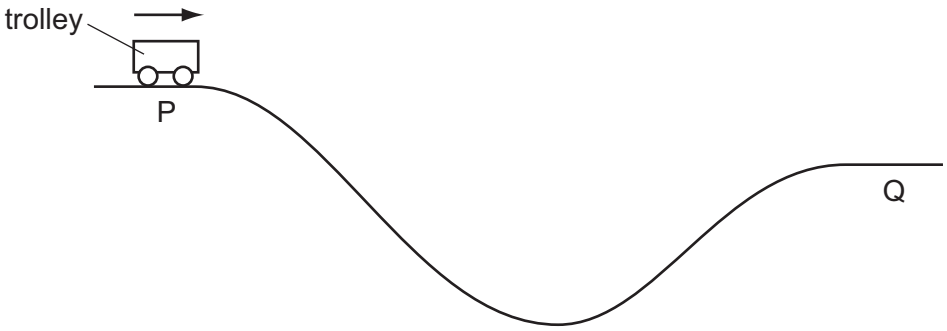
A 0 **B** $\frac{E_k}{4}$ **C** $\frac{E_k}{2}$ **D** $\frac{3E_k}{4}$

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** $kg\,m^2\,s^{-2}$ **D** $kg\,m^2\,s^{-3}$

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 2*F* is applied to the trolley over a distance of 2*s*, 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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16 A concrete cube of side 0.60 m and uniform density 2.0×10^3 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 $\dfrac{150\times10^{3}}{40\times10^{6}\times20\times60\times60}$

B $\dfrac{150\times10^{3}\times60\times60}{20\times40\times10^{6}}$

C $\dfrac{150\times10^{3}\times40\times10^{6}\times20}{60\times60}$

D $\dfrac{150\times10^{3}\times20}{40\times10^{3}\times60\times60}$

19 What is the internal energy of an object? 9702/11/M/J/12

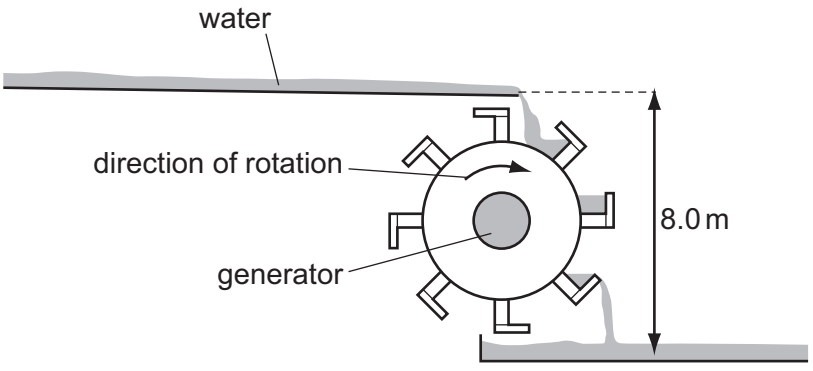
A It is the energy associated with the object's movement through space.

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?

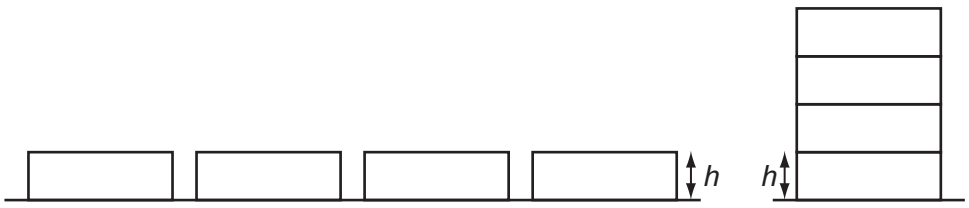
A The average velocity of the molecules will increase.

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 3 *mgh* **B** 6 *mgh* **C** 8 *mgh* **D** 10 *mgh*

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C $\dfrac{150\times10^{3}\times40\times10^{6}\times20}{60\times60}$

D $\dfrac{150\times10^{3}\times20}{40\times10^{3}\times60\times60}$

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** 6.0×10^{3} J **C** 6.0×10^{5} J **D** 6.0×10^{7} 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 1.7×10^{6} J **B** 3.4×10^{6} J **C** 1.7×10^{9} J **D** 3.4×10^{9} 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 1.2×10^2 J **B** 1.2×10^4 J **C** 1.2×10^6 J **D** 1.2×10^8 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 1.0×10^6 J **B** 2.0×10^6 J **C** 1.0×10^9 J **D** 2.0×10^9 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** 3.0×10^3 J **C** 3.0×10^5 J **D** 3.0×10^7 J

20 A transformer has the following input and output. 9702/13/O/N/12

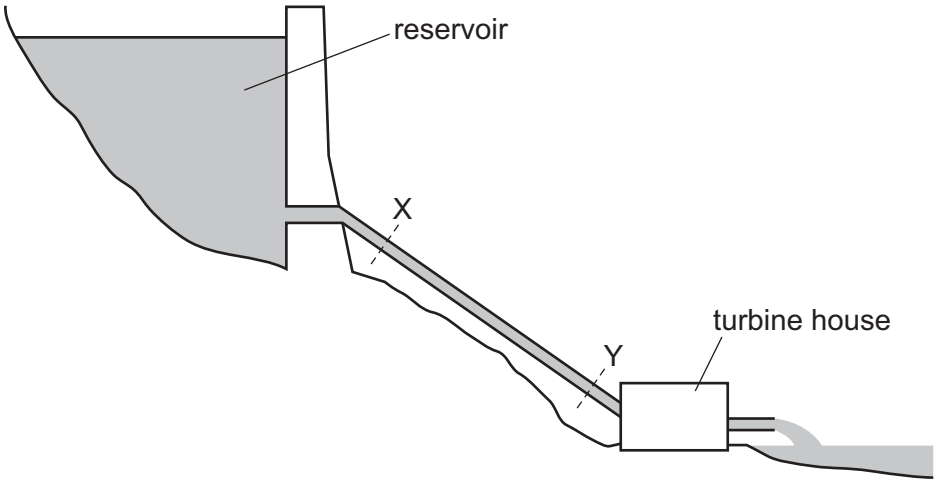
	potential difference / V	current / A
input	11 000	28
output	240	1200

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?

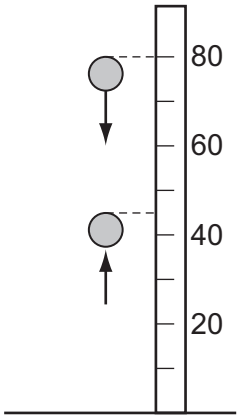
A It gains both gravitational potential energy and kinetic energy.

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

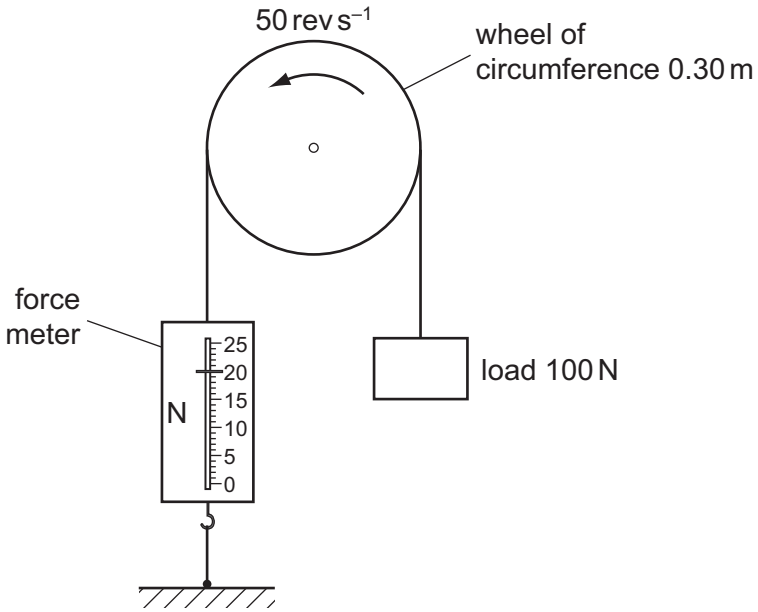


If the kinetic energy of the ball is 0.75 J just before it strikes the surface, what is its kinetic energy just after it leaves the surface?

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.

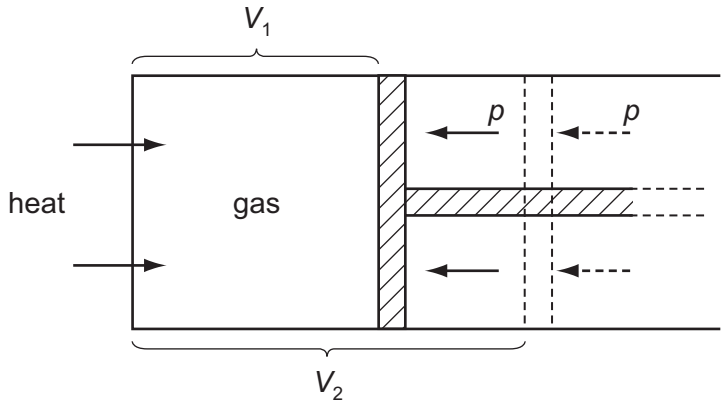
D The potential energy of the ball increases uniformly with time during its ascent.

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** $\frac{1}{2}p(V_2 + V_1)$

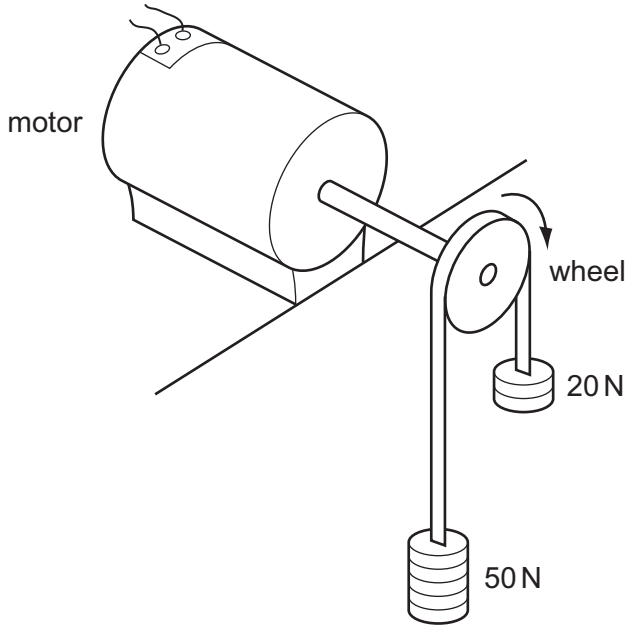
17 A train on a mountain railway is carrying 200 people of average mass 70 kg up a slope at an angle of 30° to the horizontal and at a speed of 6.0 m s^{-1}. The train itself has a mass of 80 000 kg. The percentage of the power from the engine which is used to raise the passengers and the train is 40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

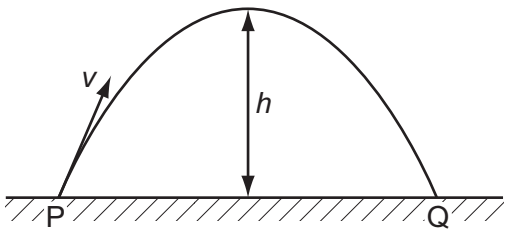
The wheel attached to the motor's axle has a circumference of 0.5 m and the belt which passes over it is stationary when the weights have the values shown.



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

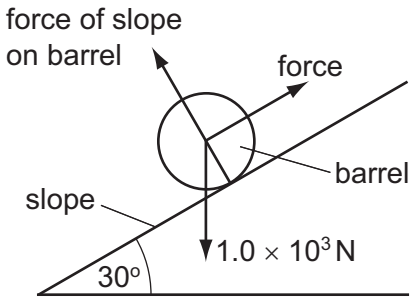
A the amount of heat supplied to the system

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 1.0×10^3 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 2.5×10^3 J **B** 4.3×10^3 J **C** 5.0×10^3 J **D** 1.0×10^4 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

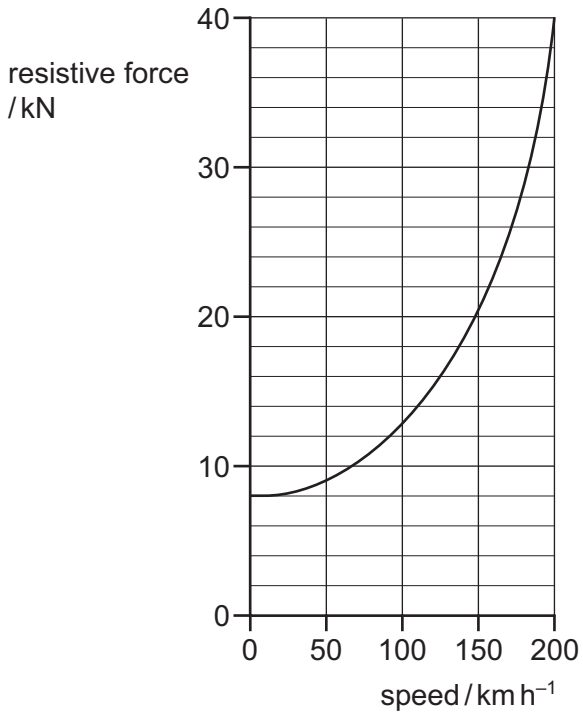
17 The pump of a water pumping system uses 2.0 kW of electrical power when raising water. The pumping system lifts 16 kg of water per second through a vertical height of 7.0 m. 9702/13/O/N/13

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

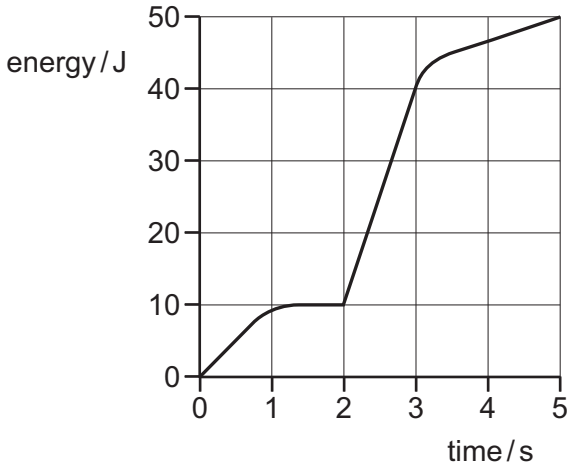
Part of this force is due to wheel friction, which is constant. The rest is due to wind resistance.



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

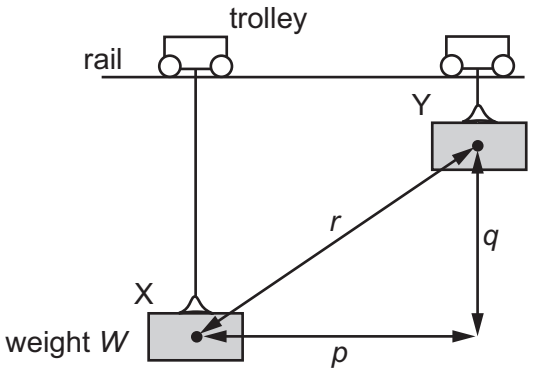
If the speed of the body is increased to $80\,m\,s^{-1}$, what is its new kinetic energy?

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?

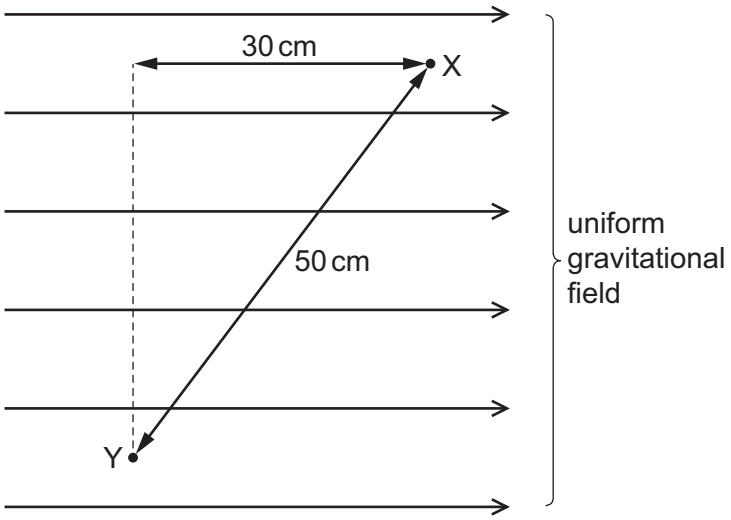
A Most of the kinetic energy is lost as heat and sound energy.

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



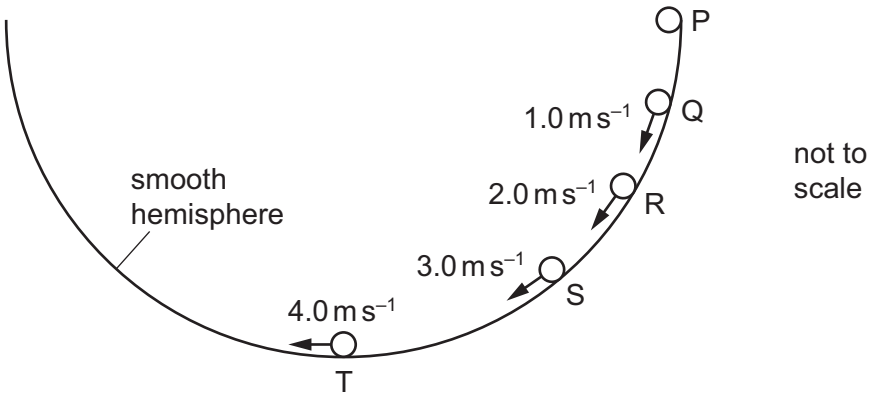
The mass is then moved to point Y.

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

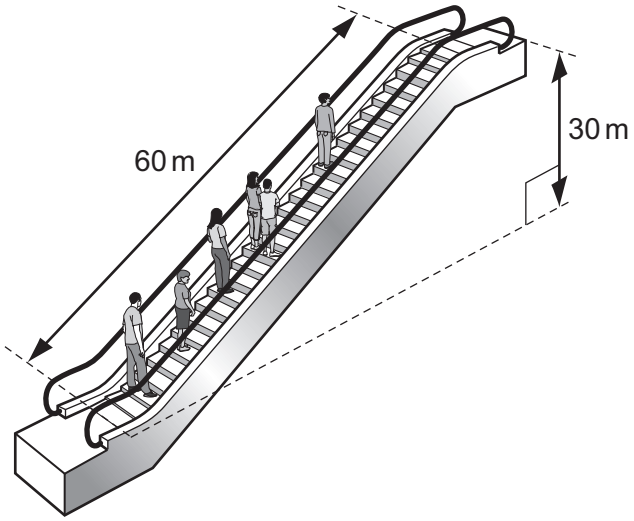
B R

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



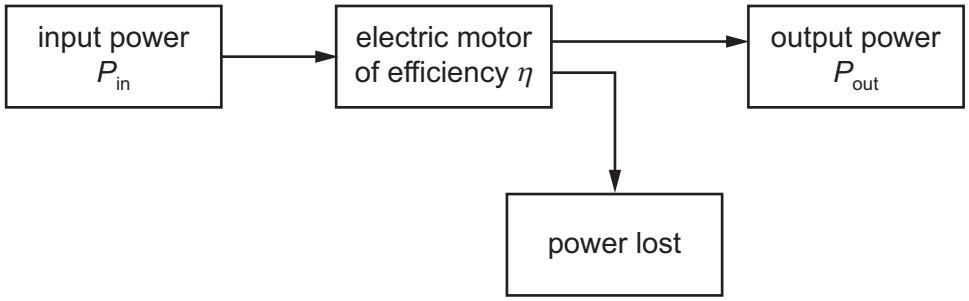
To drive the escalator against the forces of friction when there are no passengers requires a power of 2.0 kW.

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** $\left(\frac{1}{\eta}-1\right)P_{in}$ **C** ηP_{out} **D** $\left(\frac{1}{\eta}-1\right)P_{out}$

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