Name: ____________________________
HR: ____________________________
Date: ____________________________
DP Physics

ISTANBUL INTERNATIONAL COMMUNITY SCHOOL
IICS SINCE 1911

Energy, Power, Efficiency

IB Questions

(NOTE: PROBLEMS 22–26 ARE HL ONLY)

1. An object of mass m_1 has a kinetic energy K_1. Another object of mass m_2 has a kinetic energy K_2. If the momentum of both objects is the same, the ratio $\frac{K_1}{K_2}$ is equal to

A. $\frac{m_2}{m_1}$.

B. $\frac{m_1}{m_2}$.

C. $\sqrt{\frac{m_2}{m_1}}$.

D. $\sqrt{\frac{m_1}{m_2}}$.

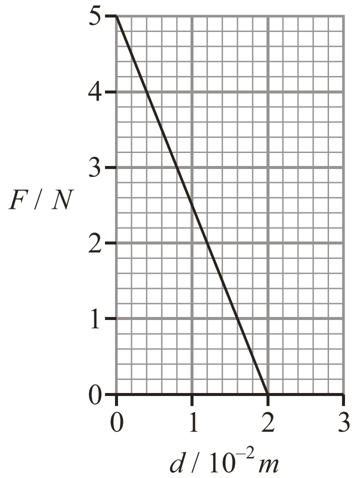
(1)

2. A rocket is fired vertically. At its highest point, it explodes. Which **one** of the following describes what happens to its total momentum and total kinetic energy as a result of the explosion?

	Total momentum	Total kinetic energy
A.	unchanged	increased
B.	unchanged	unchanged
C.	increased	increased
D.	increased	unchanged

(1)

3. The graph below shows the variation with displacement *d* of the force *F* applied by a spring on a cart.



The work done by the force in moving the cart through a distance of 2 cm is

A. 10×10^{-2}J.

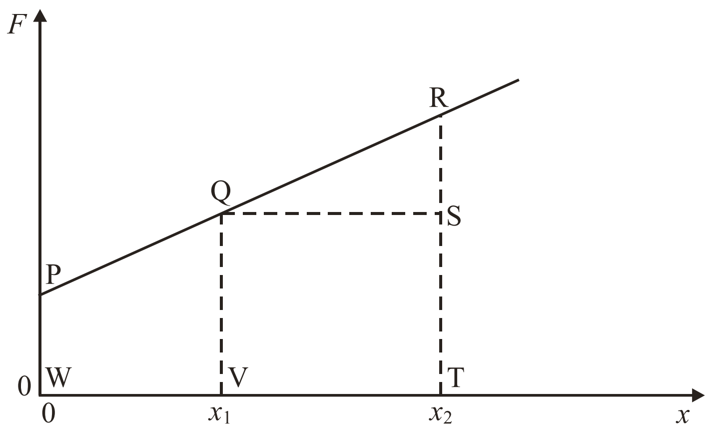
B. 7×10^{-2}J.

C. 5×10^{-2}J.

D. 2.5×10^{-2}J.

(1)

4. The diagram below shows the variation with displacement *x* of the force *F* acting on an object in the direction of the displacement.



Which area represents the work done by the force when the displacement changes from x_1 to x_2?

A. QRS

B. WPRT

C. WPQV

D. VQRT

(1)

5. This question is about the kinematics of an elevator (lift).

(a) Explain the difference between the gravitational mass and the inertial mass of an object.

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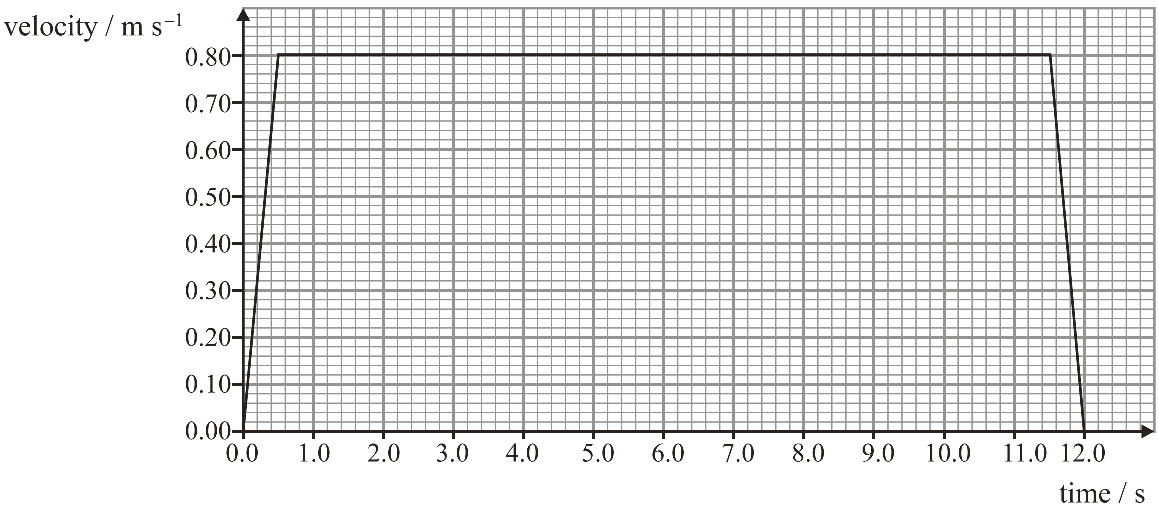
(3)

An elevator (lift) starts from rest on the ground floor and comes to rest at a higher floor. Its motion is controlled by an electric motor. A simplified graph of the variation of the elevator's velocity with time is shown below.



(b) The mass of the elevator is 250 kg. Use this information to calculate

(i) the acceleration of the elevator during the first 0.50 s.

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.... (2)

(ii) the total distance travelled by the elevator.

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.... (2)

(iii) the minimum work required to raise the elevator to the higher floor.

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.... (2)

(iv) the minimum average power required to raise the elevator to the higher floor.

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.... (2)

(v) the efficiency of the electric motor that lifts the elevator, given that the input power to the motor is 5.0 kW.

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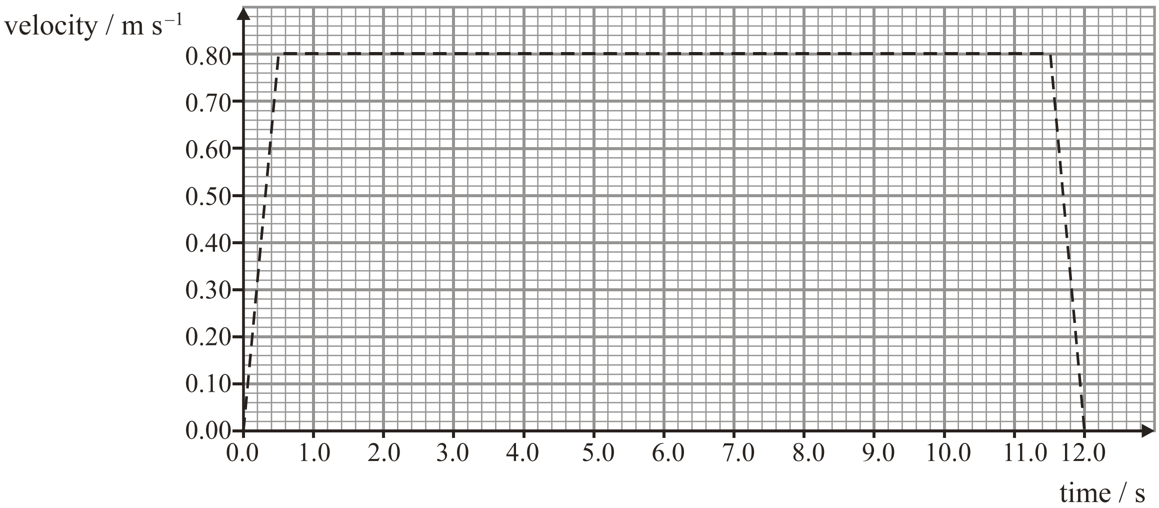
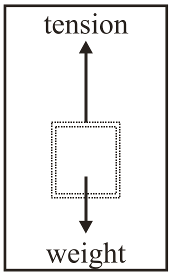
.... (2)

(c) On the graph axes below, sketch a realistic variation of velocity for the elevator. Explain your reasoning. *(The simplified version is shown as a dotted line)*



(2)

The elevator is supported by a cable. The diagram below is a free-body force diagram for when the elevator is moving upwards during the first 0.50 s.



(d) In the space below, draw free-body force diagrams for the elevator during the following time intervals.

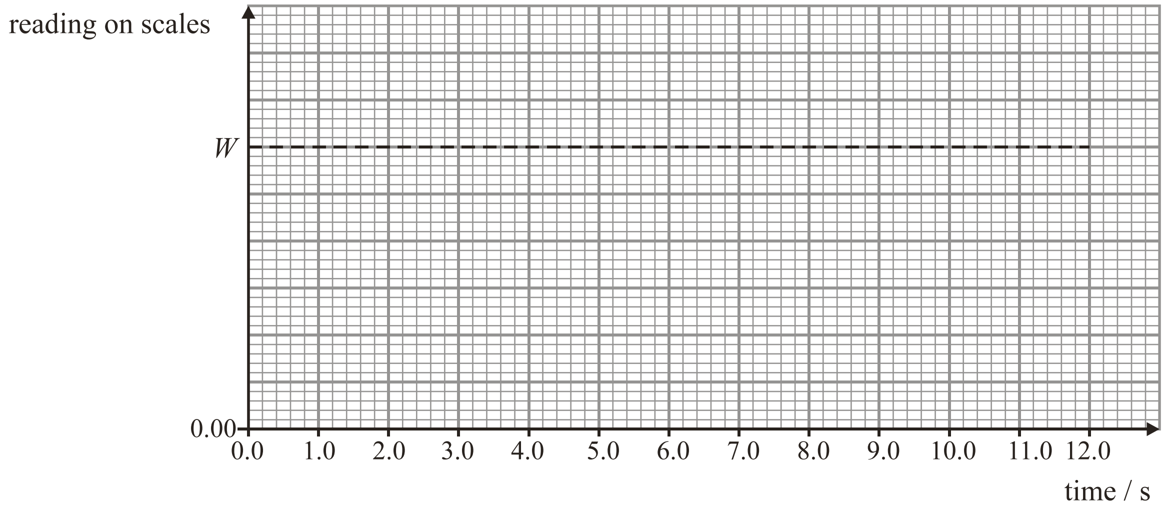
(i) 0.5 to 11.50 s

(ii) 11.50 to 12.00 s

(3)

A person is standing on weighing scales in the elevator. Before the elevator rises, the reading on the scales is *W*.

(e) On the axes below, sketch a graph to show how the reading on the scales varies during the whole 12.00 s upward journey of the elevator. *(Note that this is a sketch graph – you do not need to add any values.)*



(3)

(f) The elevator now returns to the ground floor where it comes to rest. Describe and explain the energy changes that take place during the whole up and down journey.

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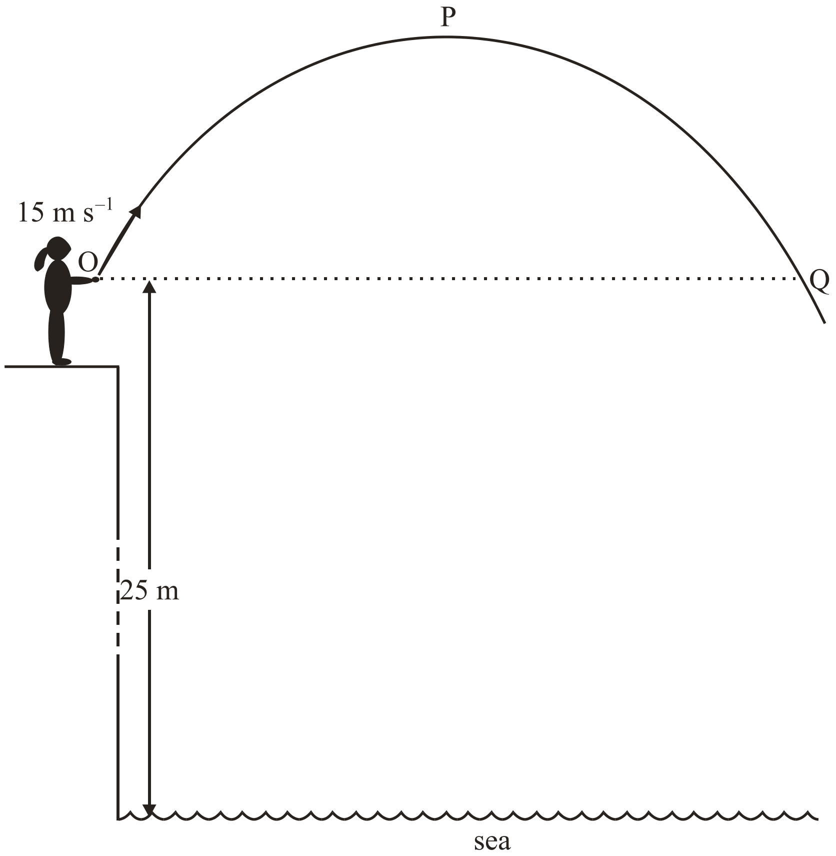
(4)

(Total 25 marks)

6. This question is about projectile motion and the use of an energy argument to find the speed with which a thrown stone lands in the sea.

Christina stands close to the edge of a vertical cliff and throws a stone. The diagram below *(not drawn to scale)* shows part of the trajectory of the stone. Air resistance is negligible.



Point P on the diagram is the highest point reached by the stone and point Q is at the same height above sea level as point O.

(a) At point P on the diagram above draw arrows to represent

(i) the acceleration of the stone (label this A). (1)

(ii) the velocity of the stone (label this V). (1)

The stone leaves Christina's hand (point O) at a speed of 15 m s^{-1} in the direction shown. Her hand is at a height of 25 m above sea level. The mass of the stone is 160 g. The acceleration due to gravity g = 10 m s^{-2}.

(b) (i) Calculate the kinetic energy of the stone immediately after it leaves Christina's hand.

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(1)

(ii) State the value of the kinetic energy at point Q.

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(1)

(iii) Calculate the loss in potential energy of the stone in falling from point Q to hitting the sea.

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(1)

(iv) Determine the speed with which the stone hits the sea.

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(2)
(Total 7 marks)

7. A machine lifts an object of weight 1.5×10^3 N to a height of 10 m. The machine has an overall efficiency of 20%. The work done by the machine in raising the object is

A. 3.0×10^3 J.

B. 1.2×10^4 J.

C. 1.8×10^4 J.

D. 7.5×10^4 J.

(1)

8. An electric train develops a power of 1.0 MW when travelling at a constant speed of 50 ms^{-1}. The net resistive force acting on the train is

A. 50 MN.

B. 200 kN.

C. 20 kN.

D. 200 N.

(1)

9. A stone of mass m is attached to a string and moves round in a horizontal circle of radius R at constant speed V. The work done by the pull of the string on the stone in one complete revolution is

A. zero.

B. $2\pi mV^2$.

C. $\frac{2\pi mV^2}{R}$.

D. $\frac{2\pi mV}{R}$.

(1)

10. This question is about the collision between two railway trucks (carts).

(a) Define *linear momentum*.

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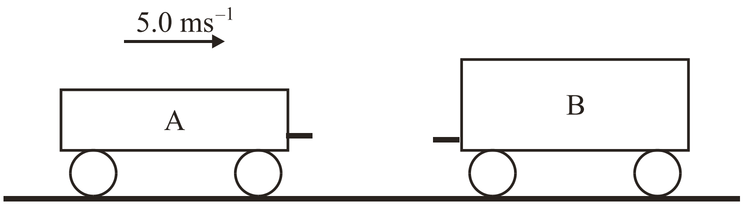
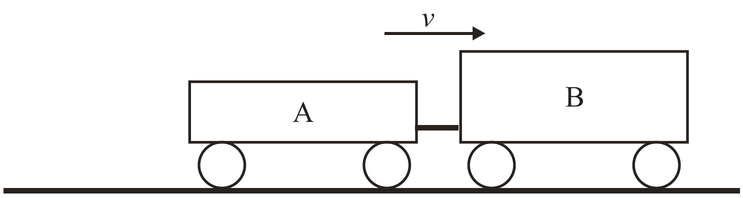
(1)

In the diagram below, railway truck A is moving along a horizontal track. It collides with a stationary truck B and on collision, the two join together. Immediately before the collision, truck A is moving with speed $5.0 ms^{-1}$. Immediately after collision, the speed of the trucks is v.



Immediately before collision



Immediately after collision

The mass of truck A is 800 kg and the mass of truck B is 1200 kg.

(b) (i) Calculate the speed v immediately after the collision.

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(3)

(ii) Calculate the total kinetic energy lost during the collision.

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(2)

(c) Suggest what has happened to the lost kinetic energy.

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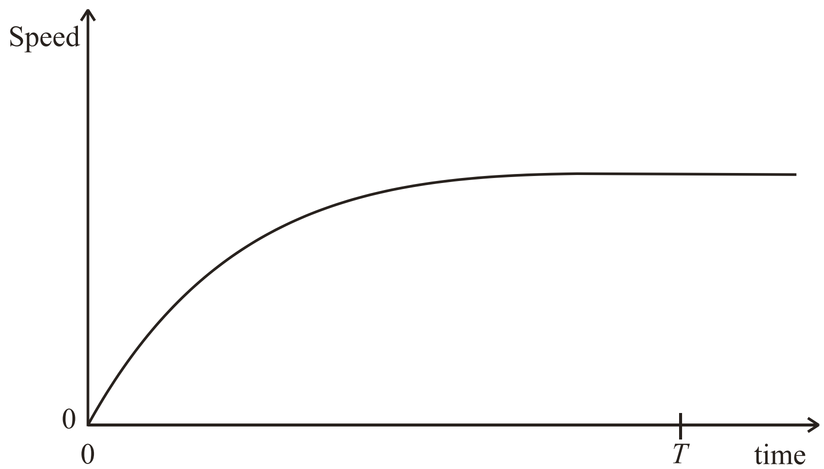
(2)
(Total 8 marks)

11. The variation with time of the vertical speed of a ball falling in air is shown below.



During the time from 0 to T, the ball gains kinetic energy and loses gravitational potential energy ΔE_p. Which of the following statements is true?

A. ΔE_p is equal to the gain in kinetic energy.

B. ΔE_p is greater than the gain in kinetic energy.

C. ΔE_p is equal to the work done against air resistance.

D. ΔE_p is less than the work done against air resistance.

(1)

12. Which of the following quantities are conserved in an inelastic collision in an isolated system of two objects?

	Linear momentum of system	Kinetic energy of system
A.	Yes	Yes
B.	Yes	No
C.	No	Yes
D.	No	No

(1)

13. Which of the following involves a change in the **total** energy of the objects?

A. Some ice and water as the ice melts at constant temperature.

B. An electron accelerated by a magnetic field.

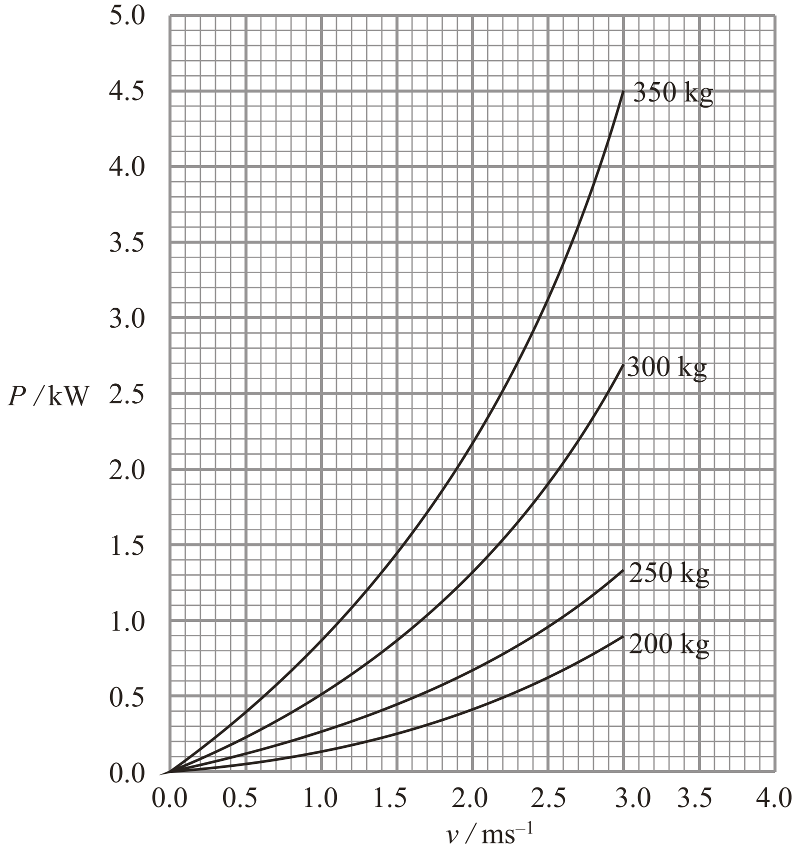
C. A satellite in a circular orbit round the Earth.

D. A stone falling in a vacuum towards the Earth's surface.

(1)

14. This question is about power output of an outboard motor.

A small boat is powered by an outboard motor of variable power P. The graph below shows the variation with speed v of P when the boat is carrying different loads.



The masses shown are the total mass of the boat plus passengers,

(a) For the boat having a steady speed of 2.0 m s^{-1} and with a total mass of 350 kg

(i) use the graph to determine the power of the engine.

.... (1)

(ii) calculate the frictional (resistive) force acting on the boat.

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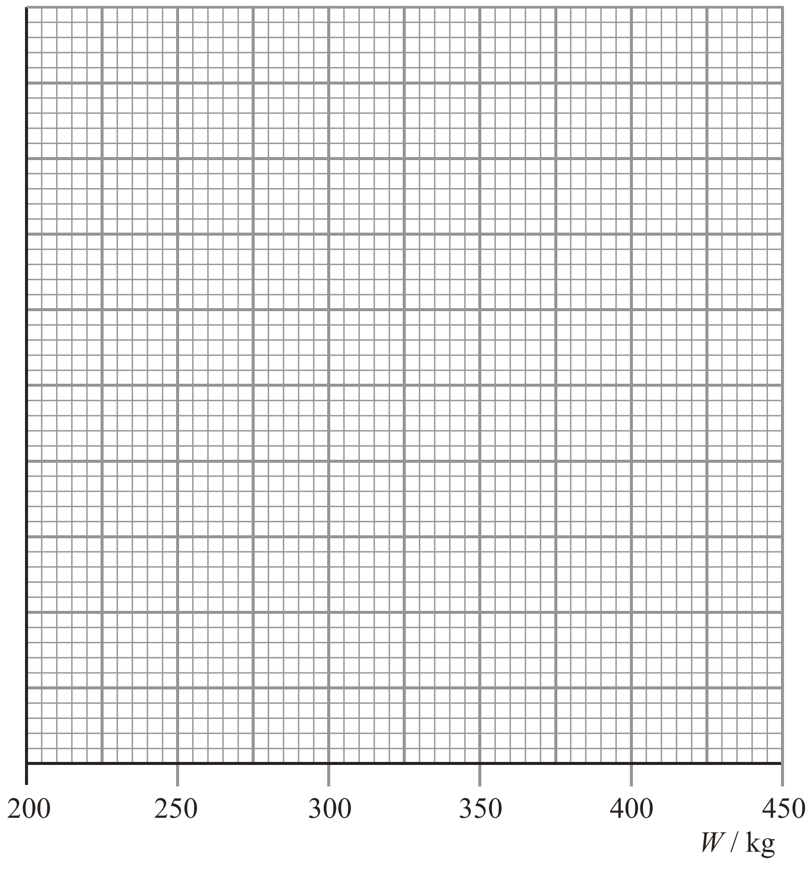
.... (2)

Consider the case of the boat moving with a speed of 2.5 m s^{-1}.

(b) (i) Use the axes below to construct a graph to show the variation of power *P* with the total mass *W*.



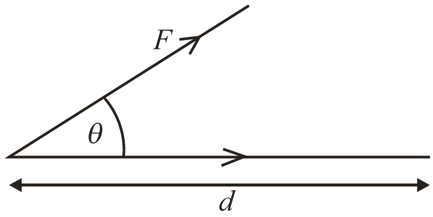
(6)

(ii) Use data from the graph that you have drawn to determine the output power of the motor for a total mass of 330 kg.

.... (1)

(Total 10 marks)

15. The point of action of a constant force F is displaced a distance d. The angle between the force and the direction of the displacement is θ, as shown below.



Which **one** of the following is the correct expression for the work done by the force?

A. Fd

B. $Fd\sin\theta$

C. $Fd\cos\theta$

D. $Fd\tan\theta$

(1)

16. Which **one** of the following is a true statement about energy?

A. Energy is destroyed due to frictional forces.

B. Energy is a measure of the ability to do work.

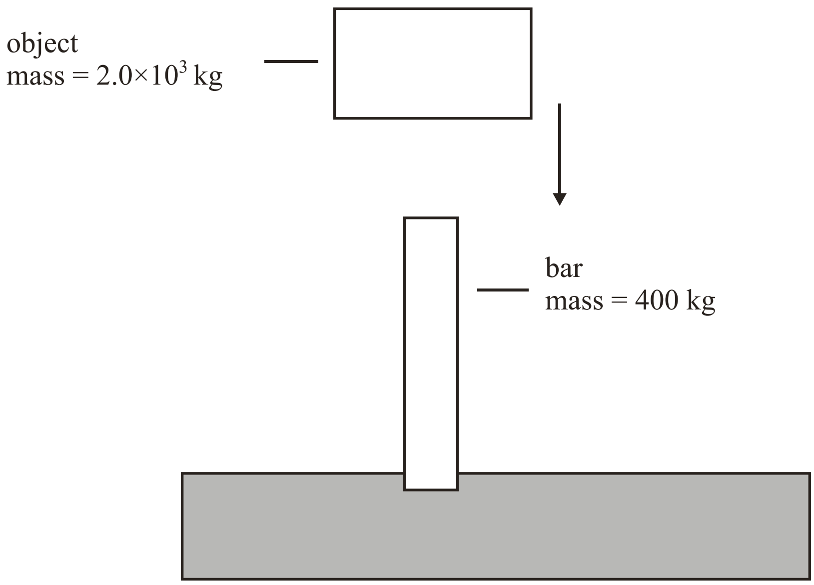
C. More energy is available when there is a larger power.

D. Energy and power both measure the same quantity.

(1)

17. This question is about driving a metal bar into the ground.

Large metal bars can be driven into the ground using a heavy falling object.



In the situation shown, the object has a mass 2.0×10^3 kg and the metal bar has a mass of 400 kg.

The object strikes the bar at a speed of 6.0 m s^{-1}. It comes to rest on the bar without bouncing. As a result of the collision, the bar is driven into the ground to a depth of 0.75 m.

(a) Determine the speed of the bar immediately after the object strikes it.

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(4)

(b) Determine the average frictional force exerted by the ground on the bar.

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(3)

(Total 7 marks)

18. A body of mass m and speed v has kinetic energy E_K. A second body of mass $\frac{m}{2}$ moves at speed $2v$.

The kinetic energy of this second body is

A. $\frac{E_K}{2}$.

B. E_K.

C. $2E_K$.

D. $4E_K$.

(1)

19. A box of mass *m* is moved horizontally against a constant frictional force *f* through a distance s at constant speed *v*. The work done on the box is

A. 0.

B. *mgs*.

C. $\frac{1}{2}mv^2$

D. *fs*.

(1)

20. An electric motor, with an input power of 250 W, produces 200 *W* of mechanical power. The efficiency of the motor is

A. 20 %.

B. 25 %.

C. 55 %.

D. 80 %.

(1)

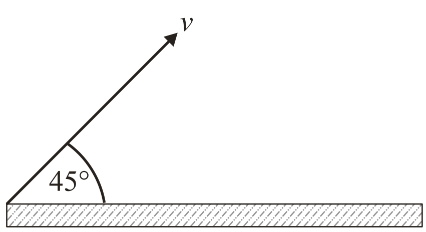
mv^2

D. *fs*.

(1)

21. This question is about projectile motion.

A projectile is fired at an angle of 45° to horizontal ground such that its speed immediately after leaving the ground is *v*.



The projectile leaves the ground at time $t = 0$ and returns to the ground at time $t = T$. Air resistance is negligible.

(a) Draw a sketch-graph, using the same set of axes, to show the variation with time t (x-axis) of the horizontal velocity v_H and vertical velocity v_V of the projectile from time $t = 0$ to time $t = T$. Label the horizontal velocity with the letter v_H and the vertical velocity with the letter v_V.

(4)

(b) On your sketch-graph, mark with the letter P, the time that corresponds to the projectile at its maximum height.

(1)

(c) The angle at which the projectile is fired is increased to more than 45°. Explain in terms of conservation of energy, why the maximum height reached by the projectile increases.

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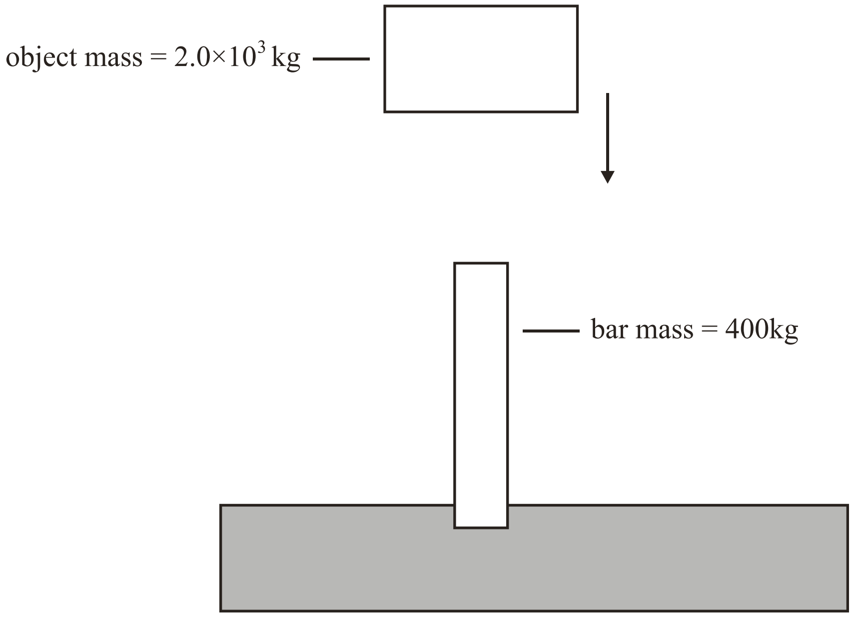
(2)

(Total 7 marks)

22. This question is about driving a metal bar into the ground and the engine used in the process.

Large metal bars can be driven into the ground using a heavy falling object.



In the situation shown, the object has a mass 2.0×10^3 kg and the metal bar has a mass of 400 kg.

The object strikes the bar at a speed of 6.0 m s^{-1} It comes to rest on the bar without bouncing. As a result of the collision, the bar is driven into the ground to a depth of 0.75 m.

(a) Determine the speed of the bar immediately after the object strikes it.

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(4)

(b) Determine the average frictional force exerted by the ground on the bar.

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(3)

(c) The object is raised by a diesel engine that has a useful power output of 7.2 kW.

In order that the falling object strikes the bar at a speed of 6.0m s^{-1}, it must be raised to a certain height above the bar. Assuming that there are no energy losses due to friction, calculate how long it takes the engine to raise the object to this height.

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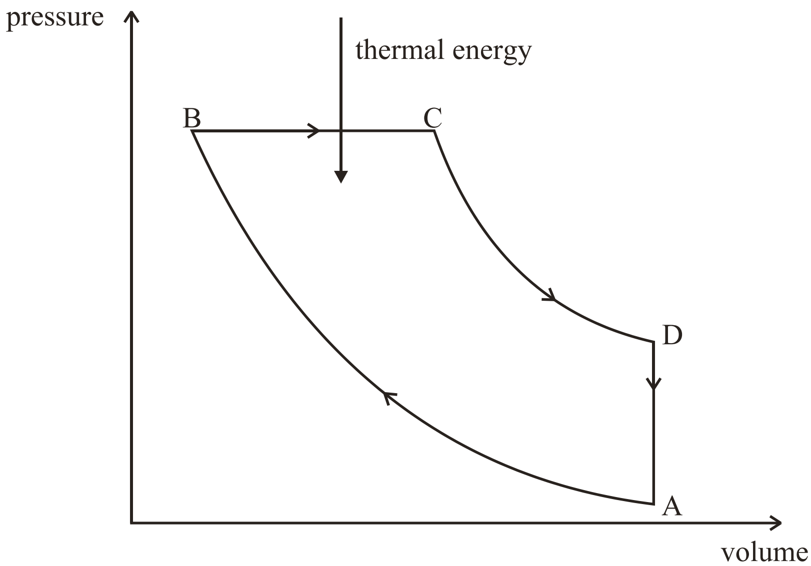
(4)

The diagram below shows the relation between the pressure and the volume of the air in the diesel engine for one cycle of operation of the engine. During the cycle there are two adiabatic processes, an isochoric process and an isobaric process.



(d) Explain what is meant by

(i) an adiabatic process.

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(2)

(ii) an isochoric process.

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.... (1)

(iii) an isobaric process.

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.... (1)

(e) Identify, from the diagram, the following processes.

(i) Adiabatic processes

.... (1)

(ii) Isochoric process

.... (1)

(iii) Isobaric process

.... (1)

During the process B ® C thermal energy is absorbed.

The diesel engine has a total power output of 8.4 kW and an efficiency of 40%. The cycle of operation is repeated 40 times every second.

(f) State what quantity is represented on the diagram by the area ABCD.

.... (1)

(g) Determine the value of the quantity that is represented by the area ABCD.

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.... (1)

(h) Determine the thermal energy absorbed during the process B ® C.

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(2)
(Total 22 marks)

23. This question is about the kinematics of an elevator (lift).

(a) Explain the difference between the gravitational mass and the inertial mass of an object.

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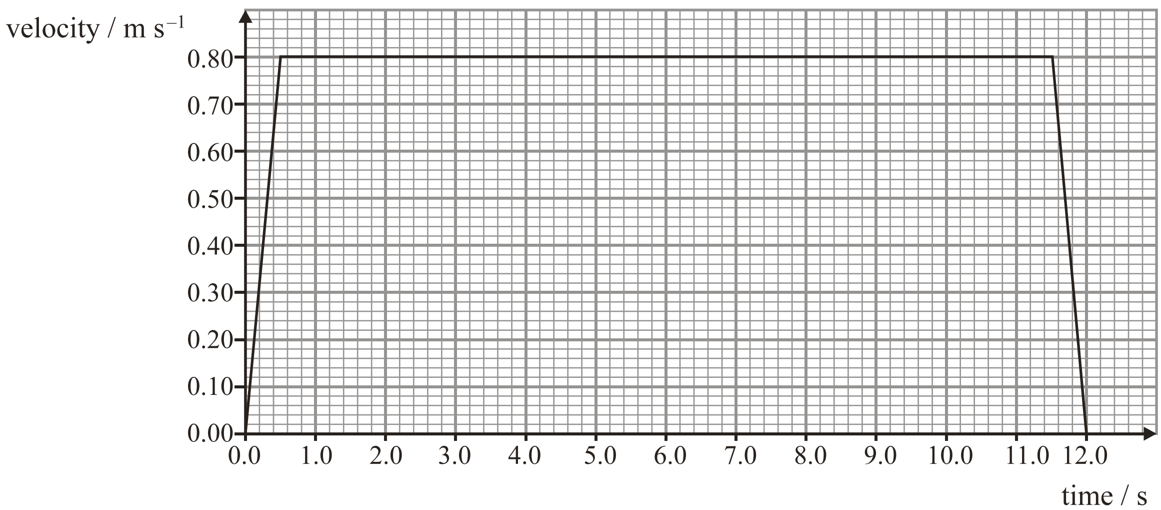
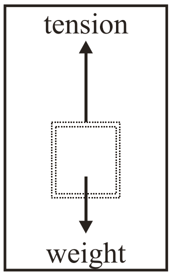
(3)

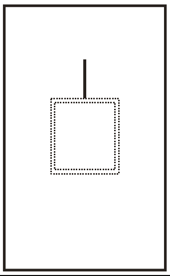
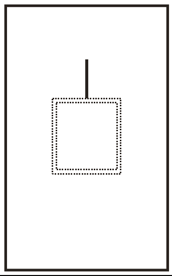
An elevator (lift) starts from rest on the ground floor and comes to rest at a higher floor. Its motion is controlled by an electric motor. A simplified graph of the variation of the elevator's velocity with time is shown below.



The elevator is supported by a cable. The diagram below is a free-body force diagram for when the elevator is moving upwards during the first 0.50 s.



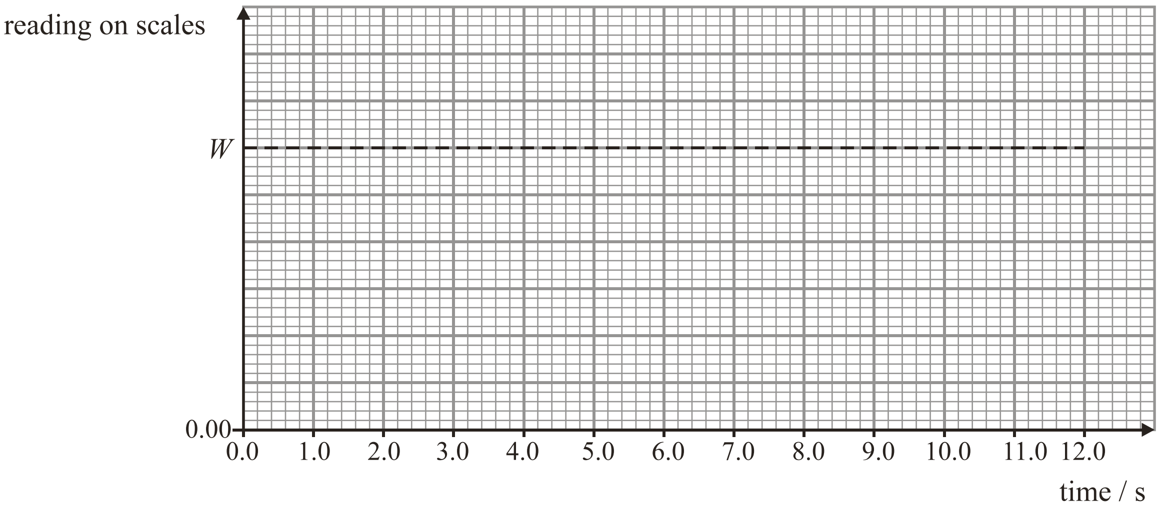
(b) In the space below, draw free-body force diagrams for the elevator during the following time intervals.

(i) 0.50 to 11.50 s	(ii) 11.50 to 12.00 s
	

(3)

A person is standing on weighing scales in the elevator. Before the elevator rises, the reading on the scales is W.

(c) On the axes below, sketch a graph to show how the reading on the scales varies during the whole 12.00 s upward journey of the elevator. *(Note that this is a sketch graph – you do not need to add any values.)*



(3)

(d) The elevator now returns to the ground floor where it comes to rest. Describe and explain the energy changes that take place during the whole up and down journey.

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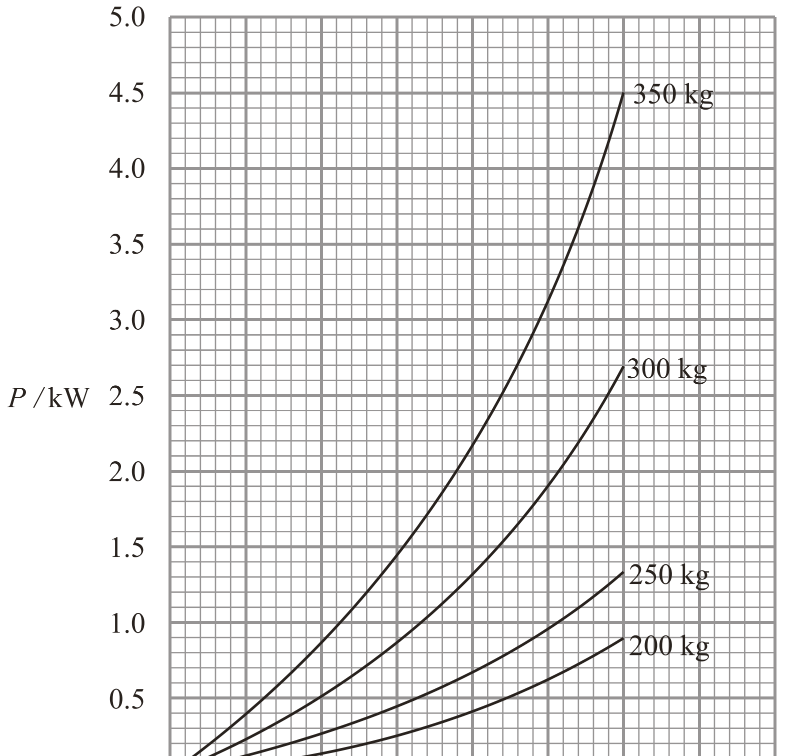
(4)

(Total 13 marks)

24. This question is about power output of an outboard motor.

A small boat is powered by an outboard motor of variable power P. The graph below shows the variation with speed v of P when the boat is carrying different loads.



The masses shown are the total mass of the boat plus passengers,

(a) For the boat having a steady speed of 2.0 m s^{-1} and with a total mass of 350 kg

(i) use the graph to determine the power of the engine.

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(ii) calculate the frictional (resistive) force acting on the boat.

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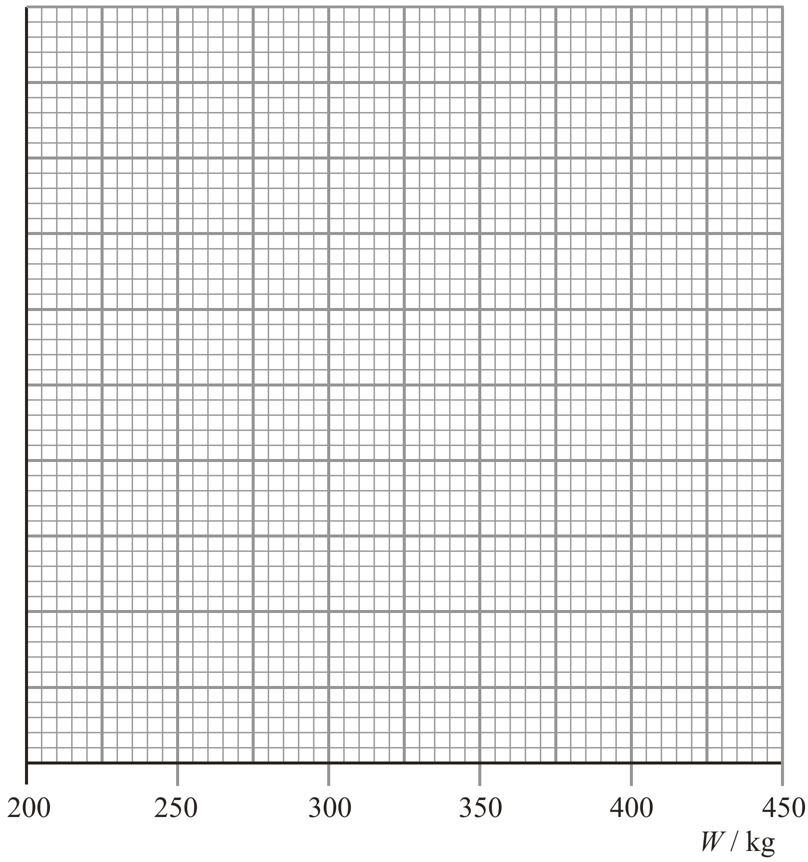
.... (2)

Consider the case of the boat moving with a speed of 2.5ms^{-1}.

(b) (i) Use the axes below to construct a graph to show the variation of power *P* with the total mass *W*.



(6)

(ii) Use data from the graph that you have drawn to determine the power of the motor for a total mass of 330 kg.

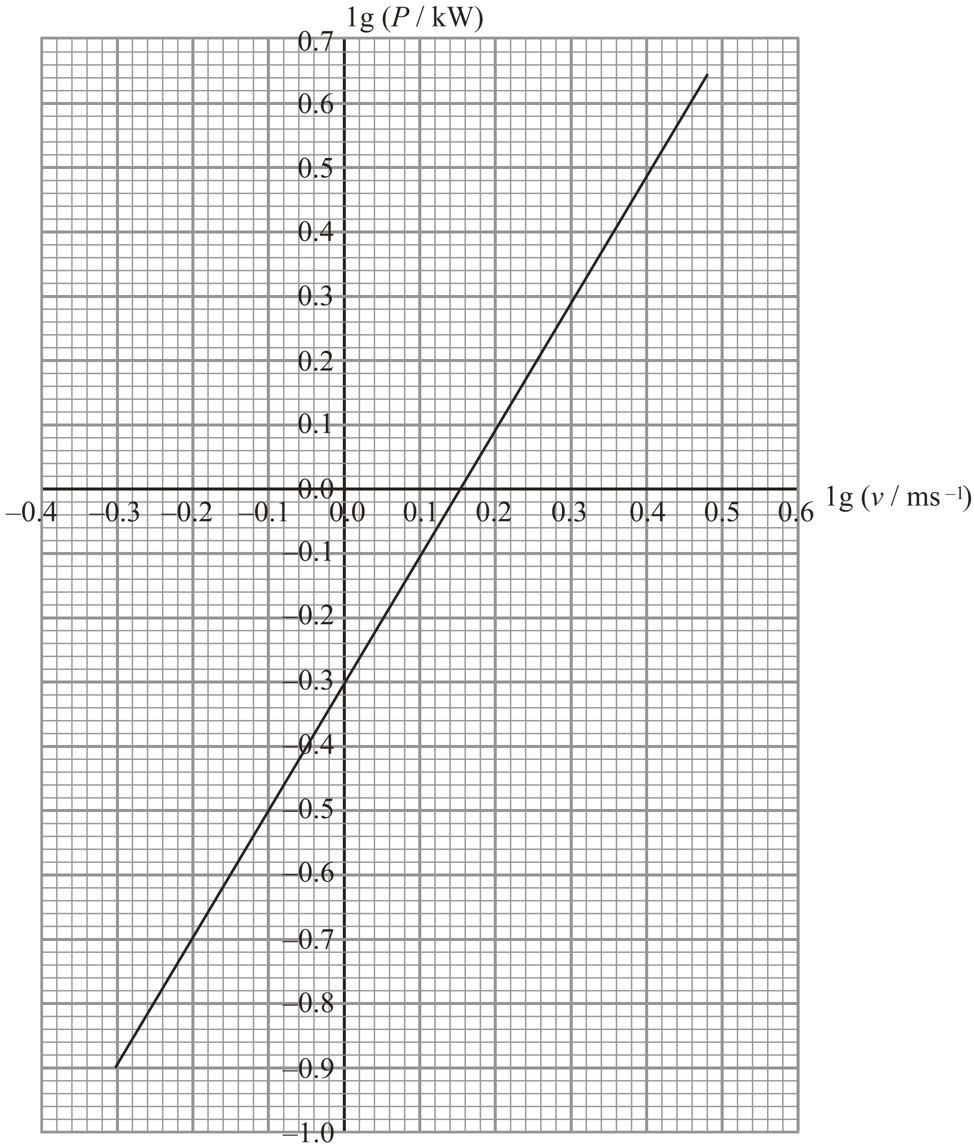
.... (1)

The relationship between power P and speed v is of the form

$$P = kv^n$$

where n is an integer and k is a constant.

The graph below shows the variation of lg v ($\log_{10} v$) with lg P ($\log_{10} P$) for the situation when the total mass is 350 kg. P is measured in kW and v is measured in m s^{-1}.



(c) Use the graph to deduce the value of n and explain how you obtained your answer.

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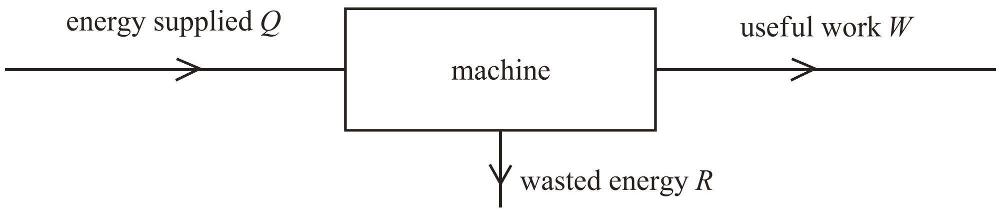
(3)
(Total 13 marks)

25. An amount Q of energy is supplied to a machine. The machine does useful work W and an amount R

of energy is wasted, as illustrated below.



Which **one** of the following is a correct expression for the efficiency of the machine?

A. $\dfrac{W}{Q}$

B. $\dfrac{R}{Q}$

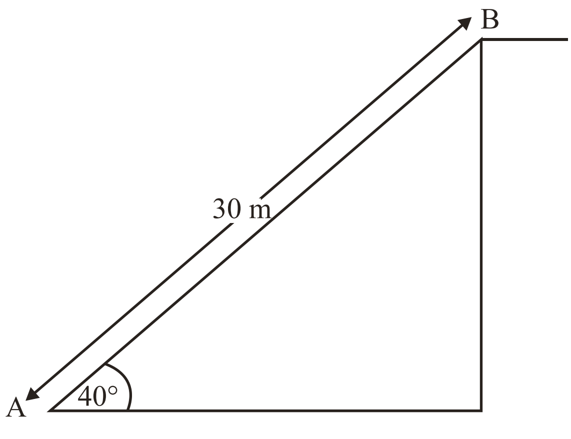
C. $\dfrac{W+R}{Q}$

D. $\dfrac{W-R}{Q}$

(1)

26. This question is about estimating the energy changes for an escalator (moving staircase).

The diagram below represents an escalator. People step on to it at point A and step off at point B.



(a) The escalator is 30 m long and makes an angle of 40° with the horizontal. At full capacity, 48 people step on at point A and step off at point B every minute.

(i) Calculate the potential energy gained by a person of weight 700 N in moving from A to B.

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.... (2)

(ii) Estimate the energy supplied by the escalator motor to the people every minute when the escalator is working at full capacity.

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.... (1)

(iii) State **one** assumption that you have made to obtain your answer to (ii).

....

.... (1)

The escalator is driven by an electric motor that has an efficiency of 70 %.

(b) (i) Using your answer to (a)(ii), calculate the minimum input power required by the motor to drive the escalator.

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.... (3)

(ii) Explain why it is not necessary to take into account the weight of the escalator when calculating the input power.

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.... (1)

(c) Explain why in practice, the power of the motor will need to be greater than that calculated in (b)(i).

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(1)

(Total 9 marks)

Name: ______________________
HR: ______________________
Date: ______________________
DP Physics

ISTANBUL INTERNATIONAL COMMUNITY SCHOOL
IICS SINCE 1911

Energy, Power, Efficiency

IB Markscheme

1. A **[1]**

2. A **[1]**

3. C **[1]**

4. D **[1]**

5. (a) statement that gravitational mass and inertial mass have the same numerical value;
understanding of what gravitational mass means;
e.g. "a quantity that determines the gravitational force on the object"
understanding of what inertial mass means;
e.g. "a quantity that determines the acceleration of the object" 3 max

(b) (i) the acceleration = gradient of first section of graph;
acceleration = 0.80 / 0.50 = 1.6 m s^{-2}; 2 max
Accept bald correct answer for full marks.

(ii) the total distance travelled by the lift = area under graph;
distance = (11 × 0.80) + (0.50 × 0.80) = 8.8 + 0.4 = 9.2 m; 2 max
Accept bald correct answer for full marks.

(iii) the work done = P.E. gained (= force × distance);
work done = 2500 × 9.2 = 23000 J = 23 kJ; 2 max
Accept bald correct answer for full marks.

(iv) correct substitution into power = work done / time taken
= 23000 / 12;
= 1916 W
= 1.9 kW; 2 max

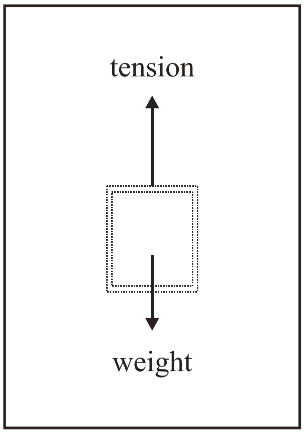
(v) correct substitution into efficiency = power out / power in
= 1.9 / 5.0;
= 0.38 = 38 %; 2 max

(c) graphs should show curving or "shoulders" at the changes;

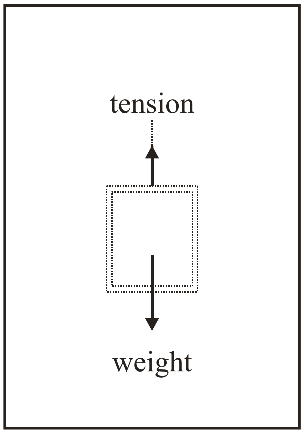
since acceleration must be finite / speed cannot change instantaneously / *OWTTE*; 2 max

(d) *Mark part (i) and (ii) together.*
weight arrow the same in both diagrams;
magnitude of tension (size of arrow) **equal to** weight in (i);
magnitude of tension (size of arrow) **less than** weight in (ii);

(i) 0.50 to 11.50 s

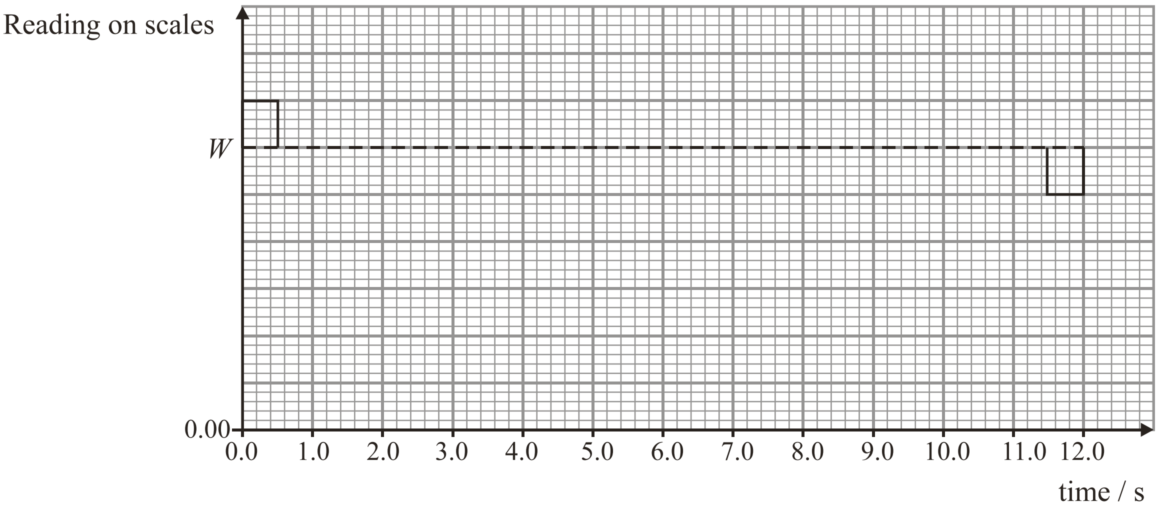


(ii) 11.50 to 12.00 s



3 max

(e) a constant value **greater** than W from 0.00 to 0.50 s;
a constant value **equal** to W from 0.50 to 11.50 s;
a constant value **less** than W from 11.50 to 12.00 s;



3 max

(f) *[1] for each appropriate and valid point. Essentially [2] for journey up and [2] for journey down. Some explanation or justification is required for full marks e.g.*
the law of conservation of energy does apply to round trip;
energy is all dissipated into heat and sound;
on the way up, most electrical energy converted into g.P.E., initially some electrical energy is converted into K.E;
on the way down electrical energy does work "breaking" lift some (not all) g.P.E. is converted into K.E.; 4 max

Reject answers that imply that P.E. converts into K.E. as lift falls.

[25]

6. (a)

(i) acceleration; 1 max

(ii) velocity; 1 max

(b) (i) $KE = \frac{1}{2}mv^2 = 0.08 \times 225 = 18$ J; 1 max

(ii) 18 J; 1 max

(iii) loss in $PE = mgh = 40$ J; 1 max

(iv) total $KE = 58$ J;
$v = \sqrt{\frac{116}{0.16}} = 27$ m s^{-1}; 2 max

[7]

7. D

[1]

8. C

[1]

9. A

[1]

10. (a) mass × velocity; 1

(b) (i) momentum before = 800 × 5 = 4 000 N s;
momentum after = 2 000v;
conservation of momentum gives $v = 2.0$ m s^{-1}; 3

(ii) KE before = 400 × 25 = 10 000 J KE after = 1 000 × 4 = 4 000 J;
loss in KE = 6 000 J; 2

(c) transformed/changed into;
heat (internal energy) (and sound); 2
Do not accept "deformation of trucks".

[8]

11. B

[1]

12. B

[1]

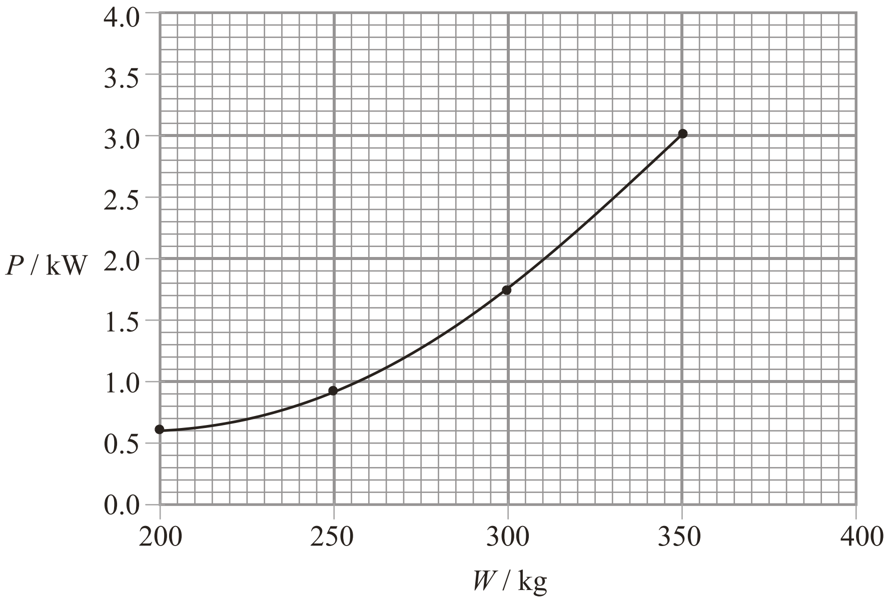
13. A

[1]

14. (a) (i) 2.0 kW; (± 0.10 kW) 1

(ii) $F = \frac{P}{v}$;
= 1000 N = ; (± 50 N) 2

(b) (i)



sensible use of grid and suitable P scale; *(at least half of grid used)*
labelled P axis with correct units;
data point (200, 0.65);
data point (250, 0.95);
data points (300, 1.9), (350, 3.1);
Allow ±0.2 kW.

line of best fit; 6

(ii) 2.6 kW; (±0.1 kW) *(watch for ecf)* 1

[10]

15. C

[1]

16. B

[1]

17. (a) momentum of object = $2 \times 10^3 \times 6.0$;
momentum after collision = $2.4 \times 10^3 \times v$;
use conservation of momentum, $2 \times 10^3 \times 6.0 = 2.4 \times 10^3 \times v$;
to get $v = 5.0 \text{ m s}^{-1}$; 4
*Award **[2 max]** for mass after collision = 400 kg and v = 30 m s^{-1}.*

(b) KE of object and bar + change in PE = $1.2 \times 10^3 \times 25 + 2.4 \times 10^3 \times 10 \times 0.7533$;
use $\Delta E = Fd$, $4.8 \times 10^4 = F \times 0.75$;
to give F = 64 kN;
*Award **[2 max]** if PE missed F = 40 kN.*

or
$a = \dfrac{v^2}{2s}$;
$F - mg = ma$;
to give F = 64kN; 3
*Award **[2 max]** if mg missed.*

[7]

18. C

[1]

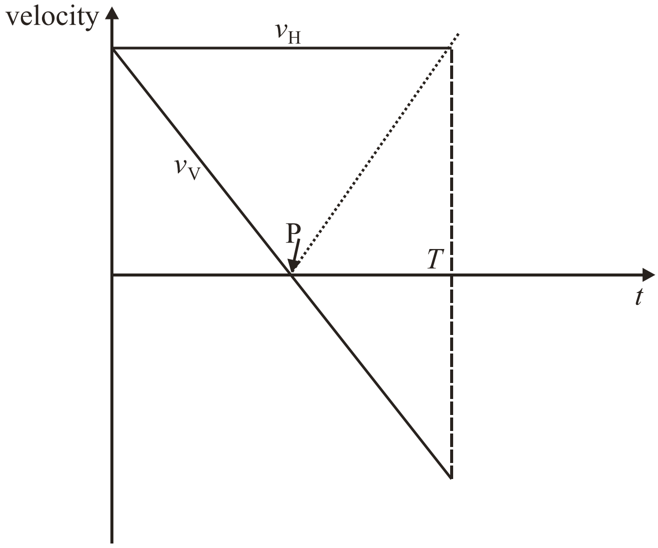
19. D

[1]

20. D

[1]

21. (a)



v_V and v_H start from the same point;
correct v_V;
correct v_H;
both ending at $t = T$; 4

Award full marks if they use the magnitude of v_v (to P and then dotted line).

(b) correct position of P; 1

(c) the vertical speed will be greater;
so more of the initial KE is used to overcome gravity /
more KE converted to PE; 2

[7]

22. (a) momentum of object = $2 \times 10^3 \times 6.0$;
momentum after collision = $2.4 \times 10^3 \times v$;
use conservation of momentum, $2 \times 10^3 \times 6.0 = 2.4 \times 10^3 \times v$;
to get $v = 5.0$ m s^{-1}; 4

*Award **[2 max]** for mass after collision = 400 kg and v = 30 m s^{-1}.*

(b) KE of object and bar + change in PE = $1.2 \times 10^3 \times 25 + 2.4 \times 10^3 \times 10 \times 0.75$;
use $\Delta E = Fd$, $4.8 \times 10^4 = F \times 0.75$;
to give F =64 kN;
*Award **[2 max]** if PE missed, F* = 40 kN.
or
$a = \frac{v2}{2s}$;
$F - mg = ma$;
to give F = 64 kN; 3

*Award **[2 max]** if mg missed.*

(c) recognize that the height is given by $mgh = \frac{1}{2}mv^2$;

$KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 2.0 \times 10^3 \times 36 = 3.6 \times 10^4$ J;

$t = \frac{E}{P}$;

$= \frac{3.6 \times 10^4}{7.2 \times 10^3}$ =5.0 s;

or

calculation of $PE = mgh$ using $v^2 = u + 2as$

$h = 1.8$ m;

$mgh = 2.0 \times 10^3 \times 10 \times 1.8$;

$t = \frac{E}{P}$;

$= \frac{3.6 \times 10^4}{7.2 \times 10^3}$ = 5.0 s; 4

(d) (i) a process in which there is no energy (heat) exchange;
between system and surrounding;
or
all the work done;
either increases or decreases the internal energy of the system; 2

(ii) a process that takes place at constant volume; 1

(iii) a process that takes place at constant pressure; 1

(e) (i) adiabatics: C → D, A → B; 1

(ii) isochoric: D → A; 1

(iii) isobaric: B → C; 1

(f) work done in one cycle; 1

(g) $\frac{8400}{40}$ = 210 J; 1

(h) $Eff = \frac{W}{Q_H}$;

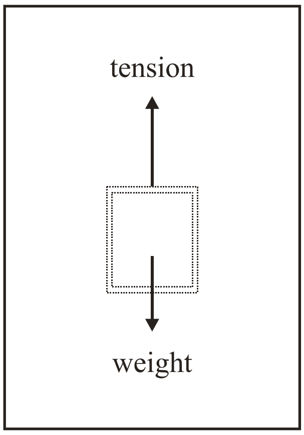
therefore, $Q_H = \frac{210}{0.4}$ = 525 J; 2

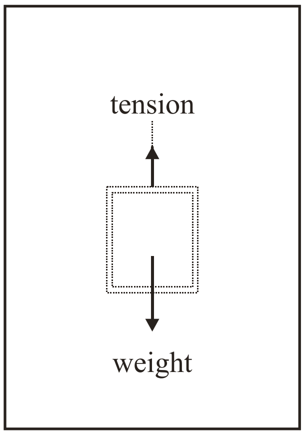
[22]

23. (a) statement that gravitational mass and inertial mass have the same numerical value;
understanding of what gravitational mass means;
e.g. "a quantity that determines the gravitational force on the object"
understanding of what inertial mass means;
e.g. "a quantity that determines the acceleration of the object" 3 max

(b) *Mark part (i) and (ii) together.*
weight arrow the same in both diagrams;
magnitude of tension (size of arrow) **equal to** weight in (i);
magnitude of tension (size of arrow) **less than** weight in (ii); 3 max

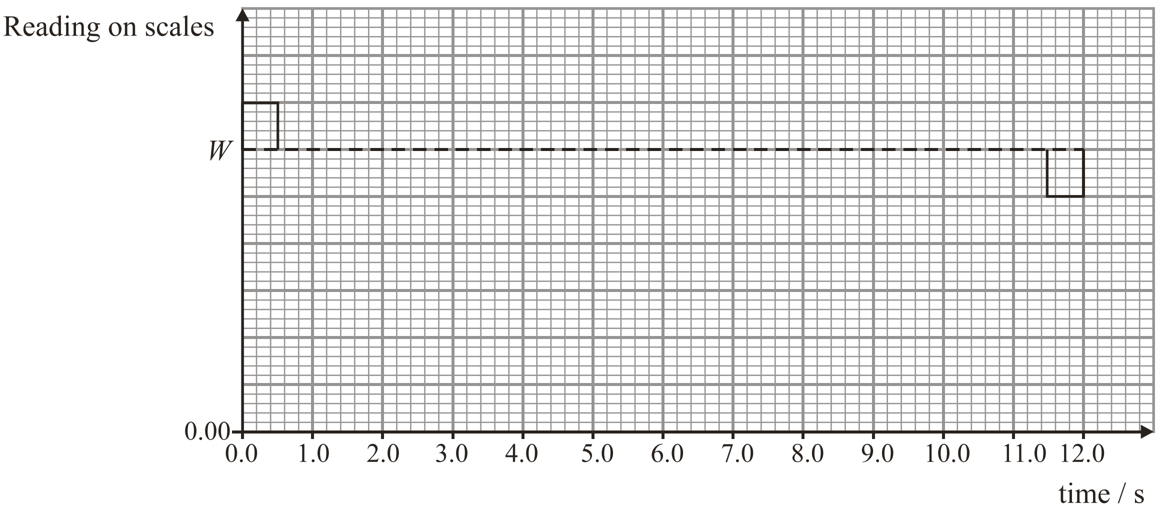
(i) 0.50 to 11.50 s (ii) 11.50 to 12.00 s





3 max

(c) a constant value **greater** than W from 0.00 to 0.50 s;
a constant value **equal** to W from 0.50 to 11.50 s;
a constant value **less** than W from 11.50 to 12.00 s;



3 max

(d) *[1] for each appropriate and valid point. Essentially [2] for journey up and [2] for journey down. Some explanation or justification is required for full marks e.g.*
the law of conservation of energy does apply to round trip;
energy is all dissipated into heat and sound;
on the way up, most electrical energy converted into g.P.E., initially some electrical energy is converted into K.E;
on the way down electrical energy does work "breaking" lift some (not all) g.P.E. is converted into K.E.; 4 max
Reject answers that imply that P.E. converts into K.E. as lift falls.

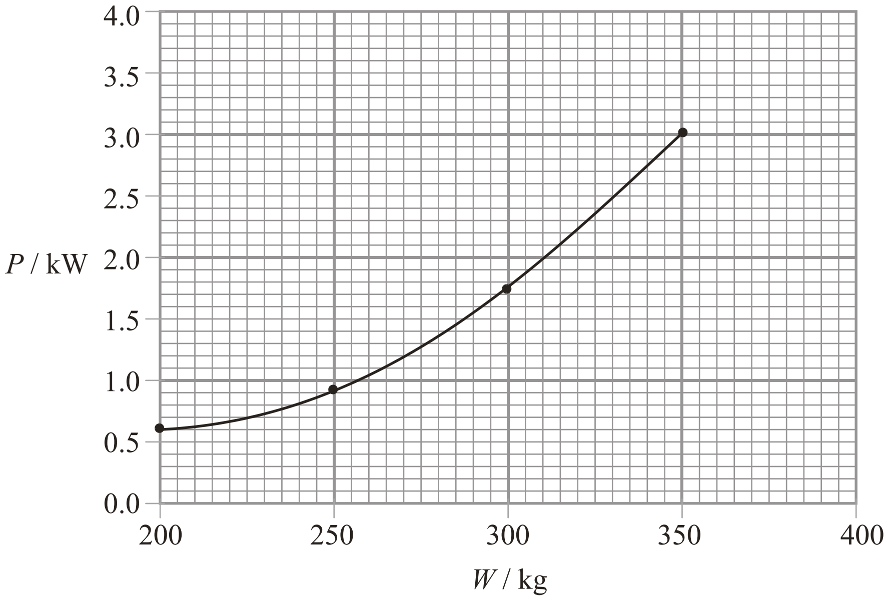
[13]

24. (a) (i) 2.0 kW; (± 0.10 kW) 1

(ii) $F = \dfrac{P}{v}$;

$= 1000$ N ; (± 50 N) 2

(b) (i)



sensible use of grid and suitable P scale; *(at least half of grid used)*
labelled P axis with correct units;
data point (200, 0.65);
data point (250, 0.95);
data points (300, 1.9), (350, 3.1);
Allow ± 0.20 kW.

line of best fit; 6

(ii) 2.6 kW; (± 0.10 kW) *(watch for ecf)* 1

(c) $\log P = n \log v + \log k$;
therefore n = slope / attempt at finding gradient shown on the graph;
choice of suitable values to show that $n = 2$ (ΔP at least 0.3); 3

[13]

25. A

[1]

26. (a) ***Note**: for part (i) and (ii) the answers in brackets are those arrived at if 19.3 is used as the value for the height.*

(i) height raised = 30 sin 40 = 19 m;
gain in PE = mgh = 700 × 19 = 1.3 × 10^4 J (1.4 × 10^4 J); 2

(ii) 48 × 1.3 × 10^4 J = 6.2 × 10^5 J (6.7 × 10^4 J); 1

(iii) the people stand still / don't walk up the escalator / their average weight is 700 N / ignore any gain in KE of the people; 1 max

(b) (i) power required = $\frac{6.2\times10^5}{60}$ = 10 kW (11 kW);
$Eff = \frac{P_{out}}{P_{in}}$, $P_{in} = \frac{P_{out}}{Eff}$;
P_{in} = 14 kW (16 kW); 3

(ii) the escalator can in theory return to the ground under the action of gravity / *OWTTE*; 1

(c) power will be lost due to friction in the escalator / *OWTTE*; 1
The location of the friction must be given to obtain the mark.

[9]