2.3 Work, Energy & Power

Question Paper

Course	DP IB Physics
Section	2. Mechanics
Topic	2.3 Work, Energy & Power
Difficulty	Hard

Time allowed: 20

Score: /10

Percentage: /100

Question 1

To exit an underground cave network, an electric winch is used to raise a lift containing the four cavers back to the surface.
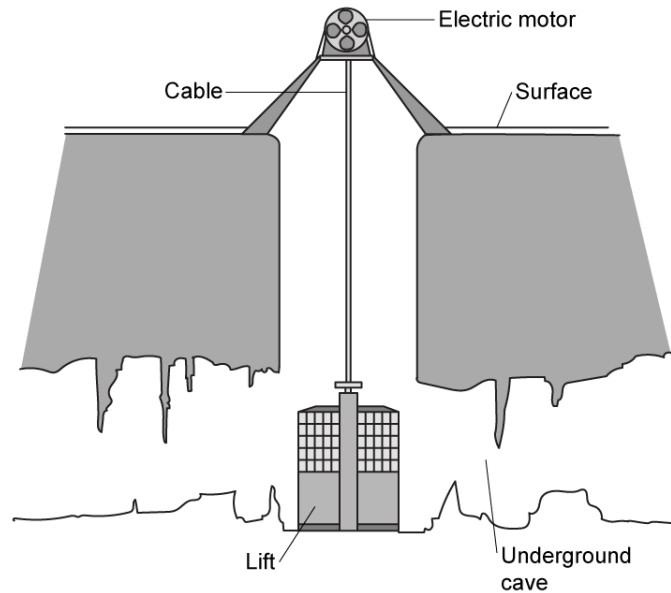
Each caver has a mass of 50 kg and the lift has a mass of 340 kg. The winch raises the lift through a vertical height of 2 km in 3 minutes.

Assuming that the acceleration due to free-fall is 10 m s^{-2}, what is the total power wasted by the winch when the motor is 75% efficient?

  A. 80 kW

  B. 20 kW

  C. 60 kW

  D. 10800 kW

[1 mark]

Question 2

A child on a swing is released from rest at position P. They move at v m s^{-1} at position Q. The mass of the child and the swing is m kg. The rope connecting the swing to the frame is l m. The positions P and Q are shown below.
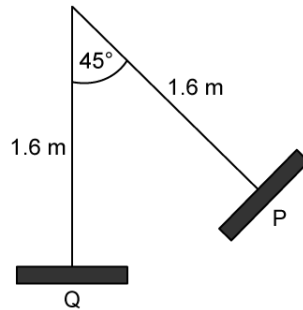
There is a constant resistive force acting on the child between P and Q.

Which expression shows the resistive force in its most simplified form?

A. $\dfrac{180gm}{\pi\theta} - \dfrac{180gm\cos\theta}{\pi\theta} - \dfrac{180mv^2}{2\pi\theta l}$
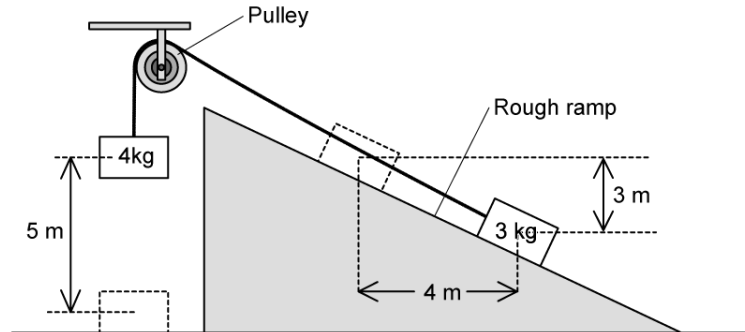
B. $\dfrac{\pi\theta l}{180}$

C. $\dfrac{90m}{\pi\theta}\left[2g(1 - \cos\theta) - \dfrac{v^2}{l}\right]$

D. $m\left[gl(1 - \cos\theta) - \dfrac{v^2}{2}\right]$

[1 mark]

Question 3

A 4 kg mass is released from rest at a height of 5 m and falls to the ground pulling a 3 kg mass up the slope. The rough surface of the ramp provides a constant frictional force of 3 N.

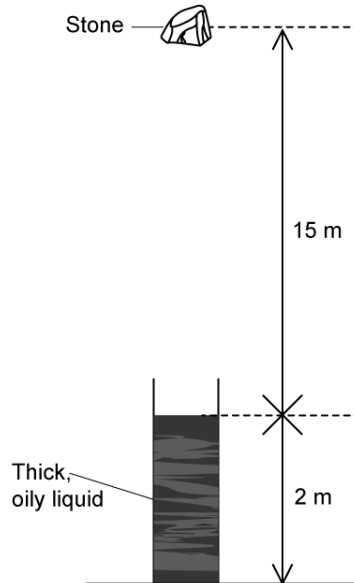Use the acceleration due to free fall $g = 10 \ \text{m s}^{-2}$.

What speed will the 4 kg mass hit the ground?

A. $\dfrac{250}{7} \ \text{m s}^{-1}$

B. $\sqrt{\dfrac{430}{7}} \ \text{m s}^{-1}$

C. $\sqrt{\dfrac{220}{7}} \ \text{m s}^{-1}$

D. $\sqrt{\dfrac{250}{7}} \ \text{m s}^{-1}$

[1 mark]

Question 4

A stone of mass m kg is dropped from a height of 15 m above the surface of a thick, oily liquid. The surface of the liquid is 2 m above the ground.

The resistive force acting on the stone as it falls through the liquid is equivalent to $3mg$ N. Assume the acceleration due to free fall $g = 10$ m s^{-2} and air resistance is negligible.
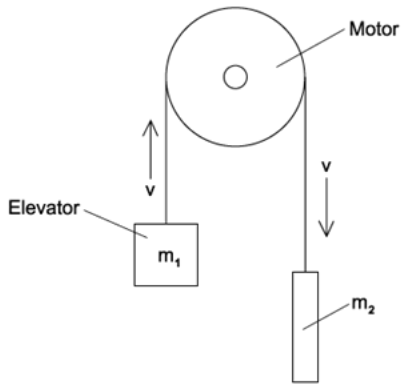
What is the speed of the stone when it has travelled x m through the liquid?

A. $2\sqrt{5(15 - 2x)}$ m s^{-1}

B. $10m(15 - 2x)$ m s^{-1}

C. $2\sqrt{5(15 - x)}$ m s^{-1}

D. $2\sqrt{15(5 - x)}$ m s^{-1}

[1 mark]

Question 5

The diagram shows a pulley in a crane system. An elevator m_1 is used to lift building materials. A counterbalance m_2 is used in the system. g is the acceleration due to free fall.
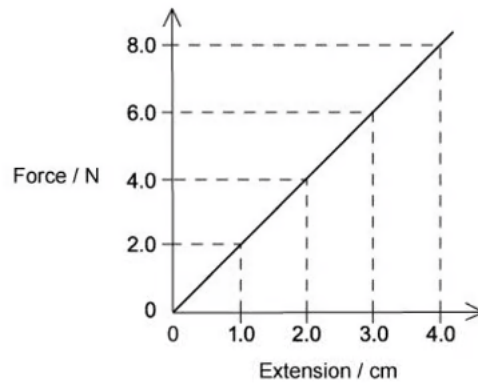

What rate does the motor provide energy to the system when the elevator is rising at a steady speed v m s^{-1}?

A. m_1gv

B. $\dfrac{1}{2}m_1v^2$

C. $gv(m_1 - m_2)$

D. $gv(m_1 + m_2)$

[1 mark]

Question 6

A wire undergoes elastic deformation. The force-extension graph is shown below.

What is the work done on the wire to increase the extension from 4.0 to 5.0 cm?

A. 0.09 J

B. 0.25 J

C. 2.0 J

D. 0.010 J

[1 mark]

Question 7

The diagram shows the design of a water wheel which drives a generator to produce electrical energy. The flow rate of the water is 100 000 g s^{-1}. The generator supplies a current of 10 A at a potential difference of 240 V. Assume the acceleration due to free fall is 10 m s^{-2}.
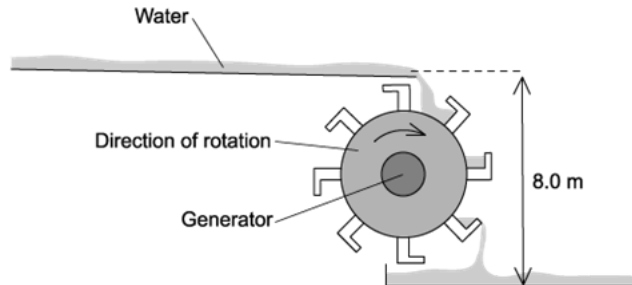
Ignore any changes in the kinetic energy of the water. What is the efficiency of the system?

A. 0.3 %

B. 3 %

C. 3.33 %

D. 30 %

[1 mark]

Question 8

A bunjee jumper has 0.036 MJ of gravitational potential energy at the top of the jump. He is attached to an elastic rope that starts to stretch after half the time of his fall has elapsed. The table below shows values of his gravitational potential energy, GPE, his kinetic energy KE, and the elastic potential energy in the rope, EPE.

	GPE / MJ	EPE / MJ	KE / MJ
Top	0.036	0	0
Bottom	0	0.036	0

What are the possible values of gravitational potential, elastic potential and kinetic energy when the bungee jumper is a quarter of the time through his fall? Assume that no energy is lost through air resistance.

	GPE / kJ	EPE / kJ	KE / kJ
A.	21	0	15
B.	9	0	27
C.	9	18	9
D.	18	9	9

[1 mark]

Question 9

A shopping mall director is considering the easiest way for shoppers to access as many floors as they can in the mall.

They are considering installing escalators that rise at 30° to the horizontal with a vertical height of 15 m. It will take 20 seconds for an escalator step to rise from the bottom to the top. The director takes the average mass of each passenger to be m kg and the acceleration due to free fall as 10 m s^{-2}.
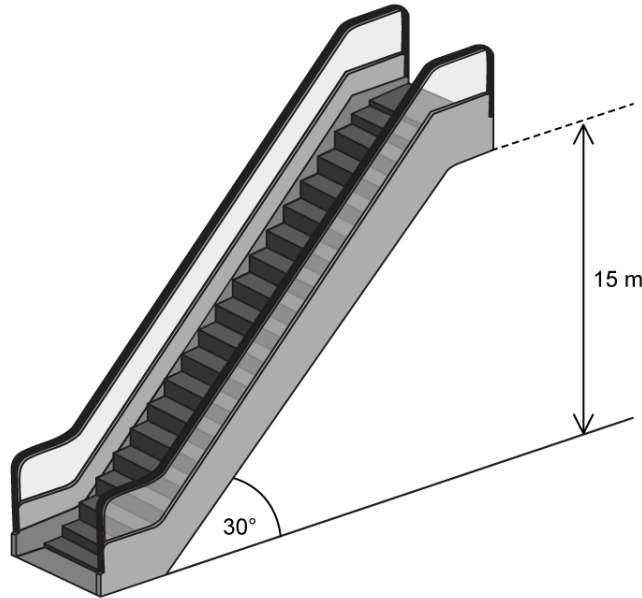
If all the passengers on the escalator stand still then 90 people can step on at the bottom and off at the top each minute.

When the escalator is fully laden with passengers the motor driving the escalator is 62.5% efficient. The magnitude of frictional forces acting on the system are equal to 20m.

What is the input power needed to operate the motor of the escalator?

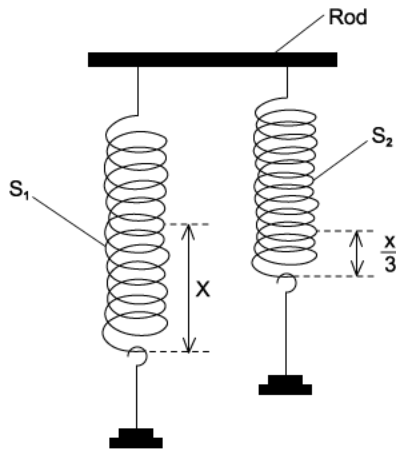You may use the following data:

$$\sin(30) = \frac{1}{2}$$

A. 384m

B. 360.8m

C. 408m

D. 360m

[1 mark]

Question 10

Two springs S_1 and S_2 hang vertically whilst being attached to a horizontal rod. A force is applied to the bottom of S_1 and it extends by x with an elastic potential energy, E in the spring.

The same load is applied to the bottom of S_2. The extension of S_2 is one third of the extension of S_1.

What is the equation for elastic potential energy in S_2?

A. $\dfrac{2E}{3}$

B. $3E$

C. $9E$

D. $\dfrac{E}{3}$

[1 mark]