

Work, Energy & Power

Question paper 6

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Work, Energy & Power
Sub Topic	
Paper Type	Theory
Booklet	Question paper 6

Time Allowed: 80 minutes

Score: /66

Percentage: /100

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

- 1 (a) A ball is thrown vertically down towards the ground and rebounds as illustrated in Fig. 2.1.

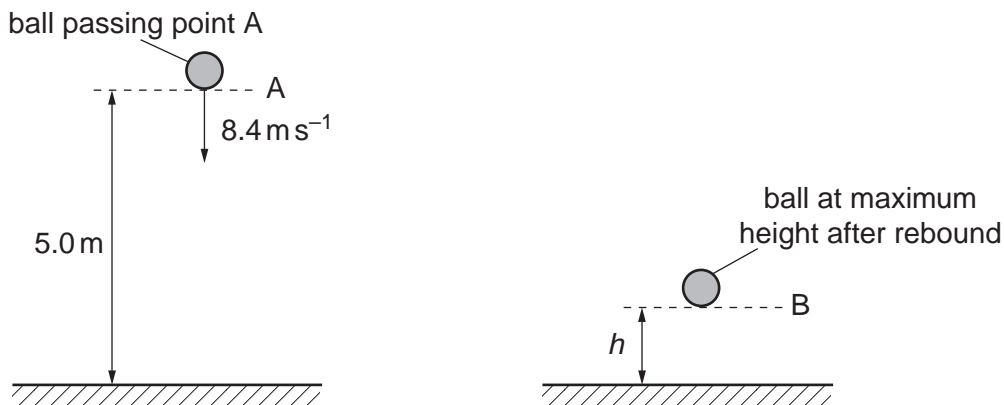


Fig. 2.1

As the ball passes A, it has a speed of 8.4ms^{-1} . The height of A is 5.0m above the ground. The ball hits the ground and rebounds to B. Assume that air resistance is negligible.

- (i) Calculate the speed of the ball as it hits the ground.

speed = ms^{-1} [2]

- (ii) Show that the time taken for the ball to reach the ground is 0.47 s.

[1]

- (b) The ball rebounds vertically with a speed of 4.2 m s^{-1} as it leaves the ground. The time the ball is in contact with the ground is 20 ms. The ball rebounds to a maximum height h .

The ball passes A at time $t = 0$. On Fig. 2.2, plot a graph to show the variation with time t of the velocity v of the ball. Continue the graph until the ball has rebounded from the ground and reaches B.

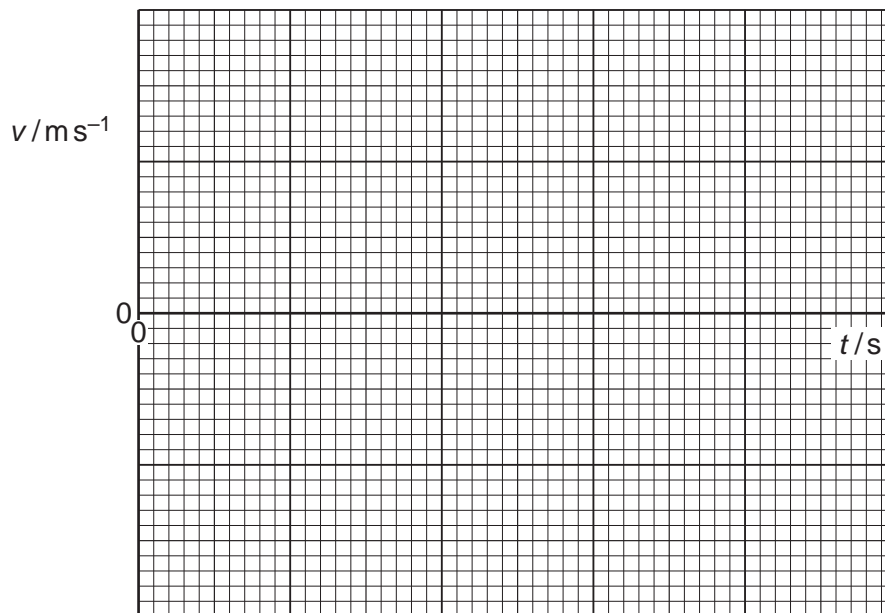


Fig. 2.2

[3]

- (c) The ball has a mass of 0.050 kg. It moves from A and reaches B after rebounding.

(i) For this motion, calculate the change in

1. kinetic energy,

change in kinetic energy = J [2]

2. gravitational potential energy.

change in potential energy = J [3]

(ii) State and explain the total change in energy of the ball for this motion.

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.....[2]

2 (a) Define *electric field strength*.

.....
 [1]

(b) A uniform electric field is produced by applying a potential difference of 1200V across two parallel metal plates in a vacuum, as shown in Fig. 4.1.

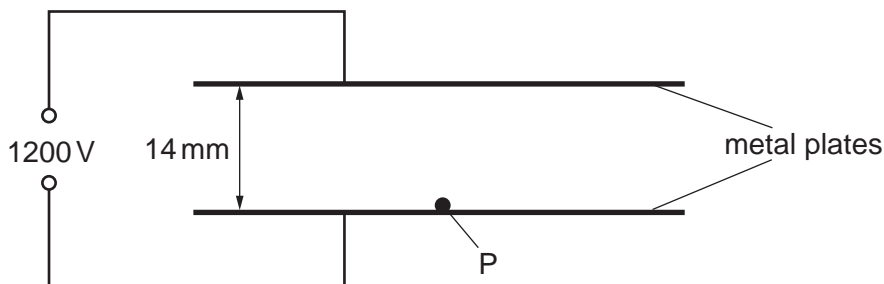


Fig. 4.1

The separation of the plates is 14 mm. A particle P with charge $3.2 \times 10^{-19} \text{ C}$ and mass $6.6 \times 10^{-27} \text{ kg}$ starts from rest at the lower plate and is moved vertically to the top plate by the electric field.

Calculate

(i) the electric field strength between the plates,

electric field strength = V m^{-1} [2]

(ii) the work done on P by the electric field,

work done = J [2]

(iii) the gain in gravitational potential energy of P,

gain in potential energy = J [2]

(iv) the gain in kinetic energy of P,

gain in kinetic energy = J [1]

(v) the speed of P when it reaches the top plate.

speed = ms^{-1} [2]

3 A ball is thrown against a vertical wall. The path of the ball is shown in Fig. 3.1.

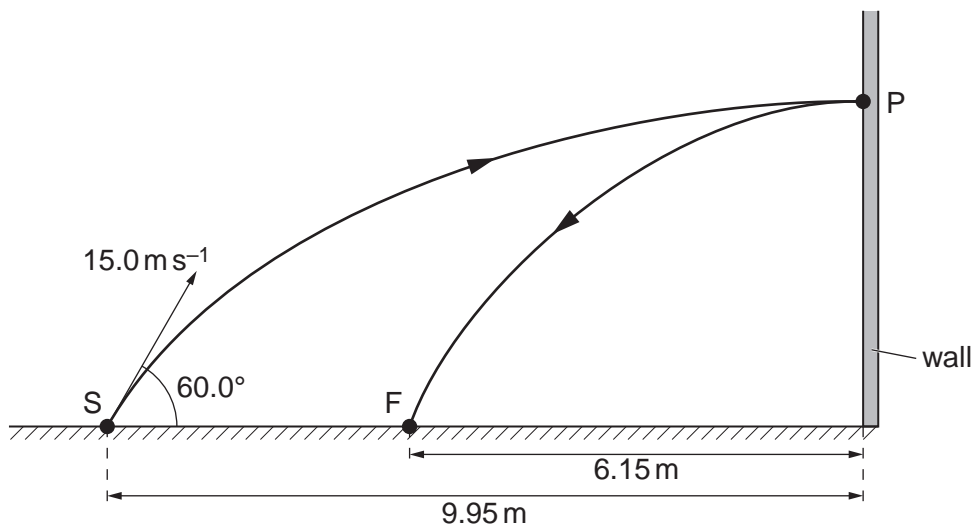


Fig. 3.1 (not to scale)

The ball is thrown from S with an initial velocity of 15.0 m s^{-1} at 60.0° to the horizontal. Assume that air resistance is negligible.

- (a) For the ball at S, calculate
- (i) its horizontal component of velocity,

horizontal component of velocity = m s^{-1} [1]

- (ii) its vertical component of velocity.

vertical component of velocity = m s^{-1} [1]

(b) The horizontal distance from S to the wall is 9.95 m . The ball hits the wall at P with a velocity that is at right angles to the wall. The ball rebounds to a point F that is 6.15 m from the wall.

Using your answers in (a),

- (i) calculate the vertical height gained by the ball when it travels from S to P,

height = m [1]

(ii) show that the time taken for the ball to travel from S to P is 1.33 s,

[1]

(iii) show that the velocity of the ball immediately after rebounding from the wall is about 4.6 m s^{-1} .

[1]

(c) The mass of the ball is $60 \times 10^{-3} \text{ kg}$.

(i) Calculate the change in momentum of the ball as it rebounds from the wall.

change in momentum = N s [2]

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

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..... [1]

4 (a) Define the terms

(i) *power*,

..... [1]

(ii) the *Young modulus*.

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..... [1]

(b) A crane is used to lift heavy objects, as shown in Fig. 3.1.

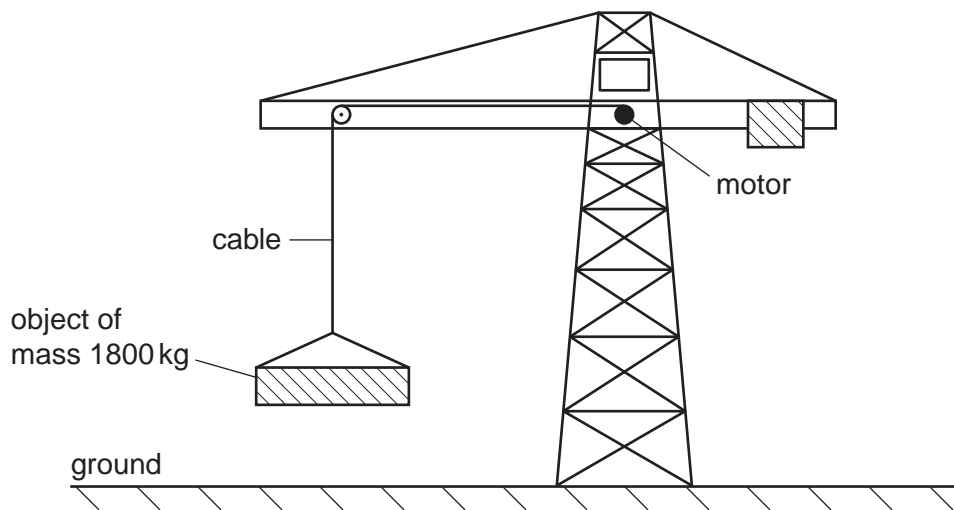


Fig. 3.1

The motor in the crane lifts a total mass of 1800 kg from rest on the ground. The cable supporting the mass is made of steel of Young modulus 2.4×10^{11} Pa. The cross-sectional area of the cable is 1.3×10^{-4} m². As the mass leaves the ground, the strain in the cable is 0.0010. Assume the weight of the cable to be negligible.

(i) 1. Use the Young Modulus of the steel to show that the tension in the cable is 3.1×10^4 N.

[2]

2. Calculate the acceleration of the mass as it is lifted from the ground.

acceleration = ms⁻² [3]

(ii) The motor now lifts the mass through a height of 15 m at a constant speed.

Calculate

1. the tension in the lifting cable,

tension = N [1]

2. the gain in potential energy of the mass.

gain in potential energy = J [2]

(iii) The motor of the crane is 30% efficient. Calculate the input power to the motor required to lift the mass at a constant speed of 0.55 m s^{-1} .

input power = W [3]

5 (a) The variation with extension x of the tension F in a spring is shown in Fig. 3.1.

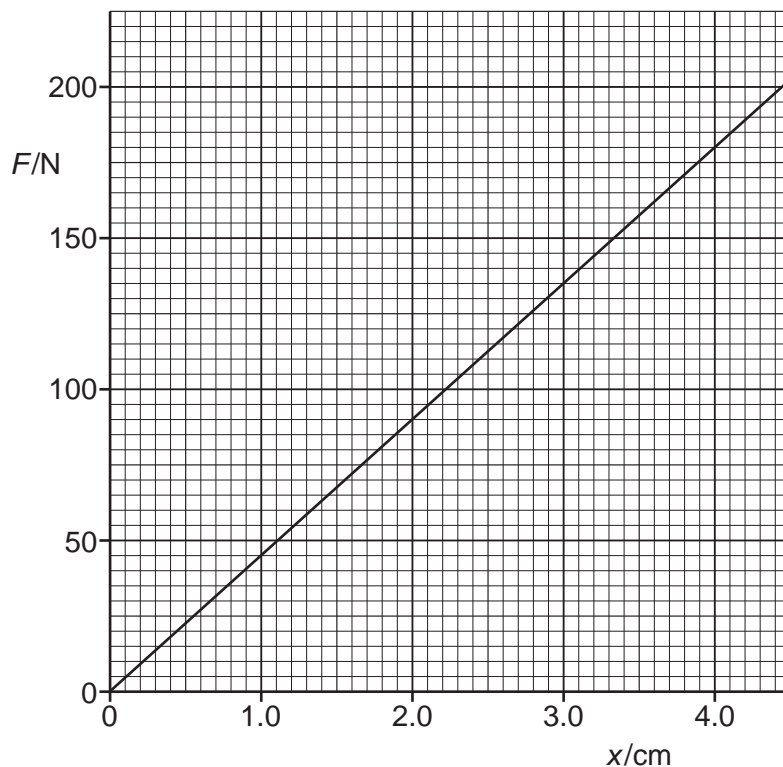


Fig. 3.1

Use Fig. 3.1 to calculate the energy stored in the spring for an extension of 4.0 cm. Explain your working.

energy = J [3]

- (b) The spring in (a) is used to join together two frictionless trolleys A and B of mass M_1 and M_2 respectively, as shown in Fig. 3.2.

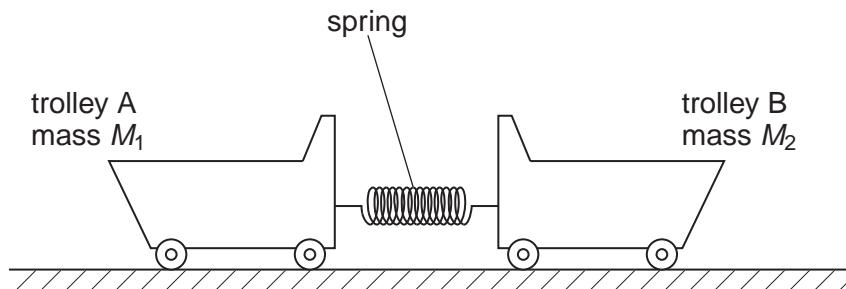


Fig. 3.2

The trolleys rest on a horizontal surface and are held apart so that the spring is extended.

The trolleys are then released.

- (i) Explain why, as the extension of the spring is reduced, the momentum of trolley A is equal in magnitude but opposite in direction to the momentum of trolley B.

.....

 [2]

- (ii) At the instant when the extension of the spring is zero, trolley A has speed V_1 and trolley B has speed V_2 . Write down

1. an equation, based on momentum, to relate V_1 and V_2 ,

.....
 [1]

2. an equation to relate the initial energy E stored in the spring to the final energies of the trolleys.

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 [1]

- (iii) 1. Show that the kinetic energy E_K of an object of mass m is related to its momentum p by the expression

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

[1]

2. Trolley A has a larger mass than trolley B.
Use your answer in **(ii) part 1** to deduce which trolley, A or B, has the larger kinetic energy at the instant when the extension of the spring is zero.

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.....[1]

- 6 A cyclist is moving up a slope that has a constant gradient. The cyclist takes 8.0s to climb the slope.
The variation with time t of the speed v of the cyclist is shown in Fig. 3.1.

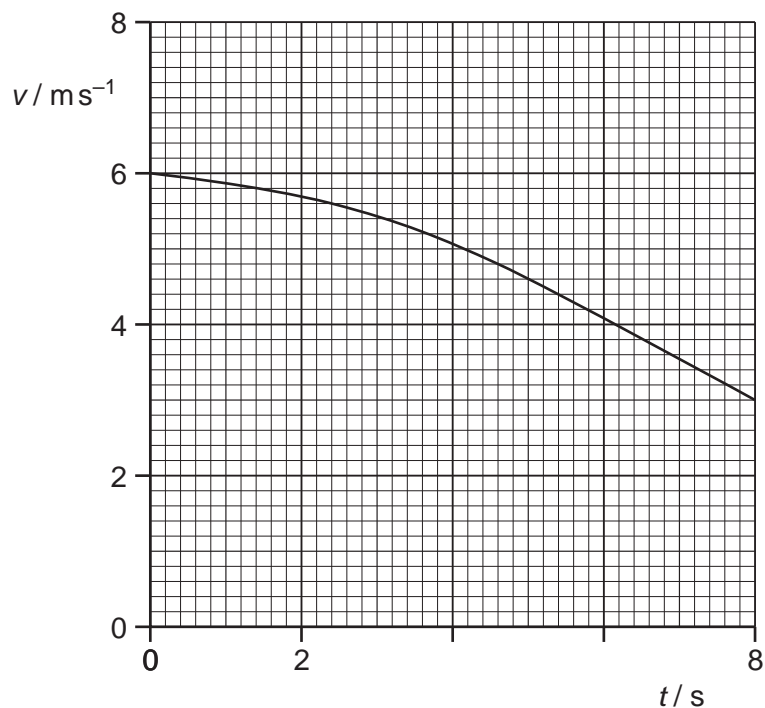


Fig. 3.1

- (a) Use Fig. 3.1 to determine the total distance moved up the slope.

distance = m [3]

(b) The bicycle and cyclist have a combined mass of 92 kg.
The vertical height through which the cyclist moves is 1.3 m.

(i) For the movement of the bicycle and cyclist between $t = 0$ and $t = 8.0$ s,

1. use Fig. 3.1 to calculate the change in kinetic energy,

change = J [2]

2. calculate the change in gravitational potential energy.

change = J [2]

(ii) The cyclist pedals continuously so that the useful power delivered to the bicycle is 75 W.

Calculate the useful work done by the cyclist climbing up the slope.

work done = J [2]

- (c) Some energy is used in overcoming frictional forces.
 - (i) Use your answers in (b) to show that the total energy converted in overcoming frictional forces is approximately 670 J.

[1]

- (ii) Determine the average magnitude of the frictional forces.

average force =N [1]

- (d) Suggest why the magnitude of the total resistive force would not be constant.

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