Work, Energy & Power

1. Nov 01-Q/4
A sphere has volume V and is made of metal of density ρ.
(a) Write down an expression for the mass m of the sphere in terms of V and ρ. [1]
(b) The sphere is immersed in a liquid. Explain the apparent loss in the weight of the sphere. [3]
(c) The sphere in (b) has mass 2.0×10^{-3} kg. When the sphere is released, it eventually falls in the liquid with a constant speed of 6.0 cms^{-1}.

(i) For this sphere travelling at constant speed, calculate
1. its kinetic energy, kinetic energy = ... J
2. its rate of loss of gravitational potential energy.
rate = ... J s^{-1} [5]
(ii) Suggest why it is possible for the sphere to have constant kinetic energy whilst losing potential energy at a steady rate.[2]

2. May 02-Q/4
A steel ball of mass 73 g is held 1.6 m above a horizontal steel plate, as illustrated in Fig. 4.1.

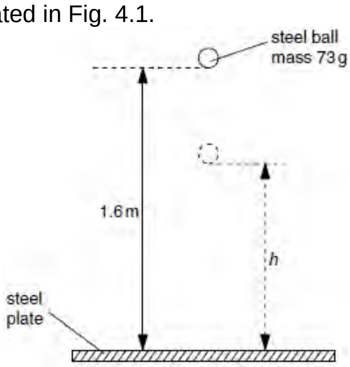

Fig. 4.1

The ball is dropped from rest and it bounces on the plate, reaching a height h.
(a) Calculate the speed of the ball as it reaches the plate.
speed = ... ms–1 [2]
(b) As the ball loses contact with the plate after bouncing, the kinetic energy of the ball is 90% of that just before bouncing.
Calculate
(i) the height h to which the ball bounces, h = ... m

(ii) the speed of the ball as it leaves the plate after bouncing.
speed = ... ms–1
[4]
(c) Using your answers to (a) and (b), determine the change in momentum of the ball during the bounce.
change = ... Ns [3]
(d) With reference to the law of conservation of momentum, comment on your answer to (c). [3]

3. May 02-Q/5
Some gas is contained in a cylinder by means of a moveable piston, as illustrated in Fig. 5.1.

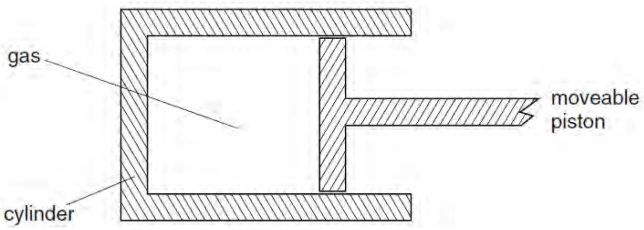

Fig. 5.1

State how, for this mass of gas, the following changes may be achieved.
(a) increase its gravitational potential energy [1]
(b) decrease its internal energy [1]
(c) increase its elastic potential energy [1]

4. May 03-Q/2
(a) (i) Define displacement.
(ii) Use your definition to explain how it is possible for a car to travel a certain distance and yet have zero displacement. [3]

(b) A car starts from rest and travels upwards along a straight road inclined at an angle of 5.0° to the horizontal , as illustrated in Fig. 2.1.

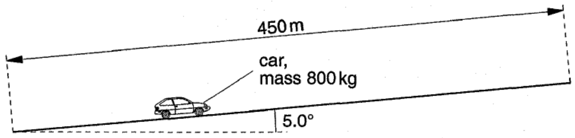

Fig. 2.1

The length of the road is 450 m and the car has mass 800 kg. The speed of the car increases at a constant rate and is 28 m s^{-1} at the top of the slope.
(i) Determine, for this car travelling up the slope, 1. its acceleration, acceleration = ... ms^{-1} [2]
2. the time taken to travel the length of the slope,
time taken = ... s [2]
3. the gain in kinetic energy,
gain in kinetic energy = ... J [2]
4. the gain in gravitational potential energy.
gain in potential energy = ... J [3]
(ii) Use your answers in (i) to determine the useful output power of the car. power= .... W [3]
(iii) Suggest one reason why the actual power output of the car engine is greater than that calculated in (ii). [2]

5. May 04-Q/4
A ball has mass m. It is dropped onto a horizontal plate as shown in Fig. 4.1.

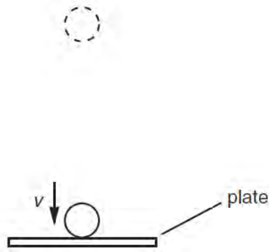

Fig. 4.1

Just as the ball makes contact with the plate, it has velocity v, momentum p and kinetic energy E_k.
(a) (i) Write down an expression for momentum p in terms of m and v.
(ii) Hence show that the kinetic energy is given by the expression

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

[3]

6. May 05-Q/3
A bullet of mass 2.0 g is fired horizontally into a block of wood of mass 600 g. The block is suspended from strings so that it is free to move in a vertical plane.
The bullet buries itself in the block. The block and bullet rise together through a vertical distance of 8.6 cm, as shown in Fig. 3.1.

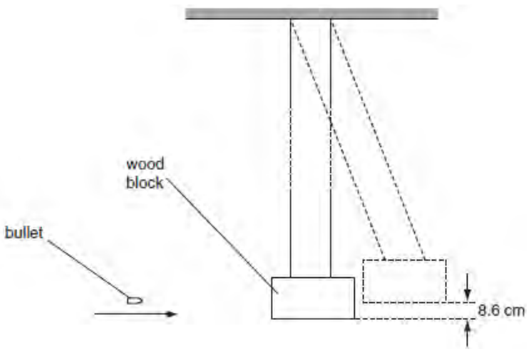

Fig. 3.1

(a) (i) Calculate the change in gravitational potential energy of the block and bullet.
change = ... J [2]
(ii) Show that the initial speed of the block and the bullet, after they began to move off together, was 1.3ms^{-1}. [1]

(b) Using the information in (a)(ii) and the principle of conservation of momentum, determine the speed of the bullet before the impact with the block.
speed = ... ms^{-1} [2]
(c) (i) Calculate the kinetic energy of the bullet just before impact. kinetic energy = ... J [2]

(ii) State and explain what can be deduced from your answers to (c)(i) and (a)(i) about the type of collision between the bullet and the block.[2]

7.Nov 05-Q/8
(a) Explain the concept of *work*. [2]
(b) A table tennis ball falls vertically through air. Fig. 8.1 shows the variation of the kinetic energy E_K of the ball with distance h fallen. The ball reaches the ground after falling through a distance h_0.

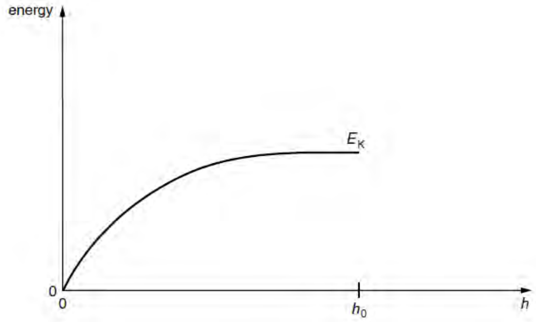

Fig. 8.1
(i) Describe the motion of the ball. [3]
(ii) On Fig. 8.1, draw a line to show the variation with h of the gravitational potential energy E_P of the ball. At $h = h_0$, the potential energy is zero. [3]

8. Nov 06-Q/1
(a) Define what is meant by
(i) *work done*, [2] (ii) *power*. [1]

(b) A force F is acting on a body that is moving with velocity v in the direction of the force. Derive an expression relating the power P dissipated by the force to F and v. [2]

(c) A car of mass 1900 kg accelerates from rest to a speed of $27ms^{-1}$ in 8.1 s.
(i) Calculate the average rate at which kinetic energy is supplied to the car during the acceleration. rate = ……………. W [2]
(ii) The car engine provides power at a constant rate. Suggest and explain why the acceleration of the car is not constant. [2]

8. Nov 06-Q/3
Francium-208 is radioactive and emits α-particles with a kinetic energy of $1.07x10^{-12}$ J to form nuclei of astatine, as illustrated in Fig. 3.1.

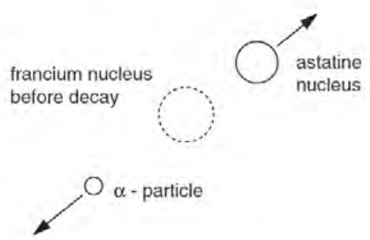

Fig. 3.1
(a) State the nature of an α-particle. [1]
(b) Show that the initial speed of an α-particle after the decay of a francium nucleus is approximately $1.8x10^7ms^{-1}$. [2]

(c) (i) State the principle of conservation of linear momentum. [2]

(ii) The Francium-208 nucleus is stationary before the decay.

Estimate the speed of the astatine nucleus immediately after the decay. speed = ……………………… ms^{-1} [3]

(d) Close examination of the decay of the francium nucleus indicates that the astatine nucleus and the α-particle are not ejected exactly in opposite directions.
Suggest an explanation for this observation. [2]

9. May 07-Q/4
(a) A stone of mass 56 g is thrown horizontally from the top of a cliff with a speed of 18 m s^{-1}, as illustrated in Fig. 4.1.

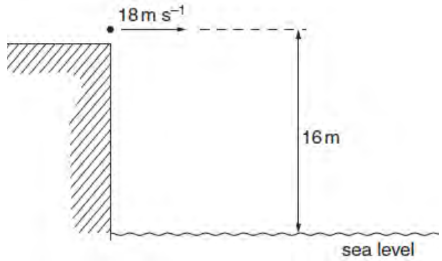

Fig. 4.1
The initial height of the stone above the level of the sea is 16 m. Air resistance may be neglected.
(i) Calculate the change in gravitational potential energy of the stone as a result of falling through 16 m.
change = ...J [2]
(ii) Calculate the total kinetic energy of the stone as it reaches the sea. kinetic energy = ... J [3]
(b) Use your answer in (a)(ii) to show that the speed of the stone as it hits the water is approximately 25 m s^{-1}. [1]
(c) State the horizontal velocity of the stone as it hits the water.
horizontal velocity = ...m s^{-1} [1]
(d) (i) On the grid of Fig. 4.2, draw a vector diagram to represent the horizontal velocity and the resultant velocity of the stone as it hits the water. [1]

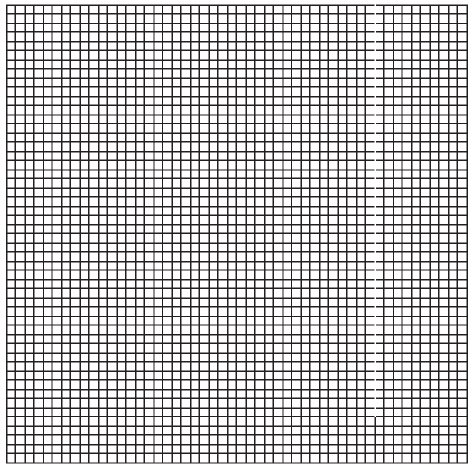

Fig. 4.2
(ii) Use your vector diagram to determine the angle with the horizontal at which the stone hits the water.
angle = ... °[2]

10.Nov 07-Q/3
(a) (i) Define potential energy. [1]
(ii) Distinguish between *gravitational* potential energy and *elastic* potential energy [2]

(b) A small sphere of mass 51 g is suspended by a light inextensible string from a fixed point P.
The centre of the sphere is 61 cm vertically below point P, as shown in Fig. 3.1.

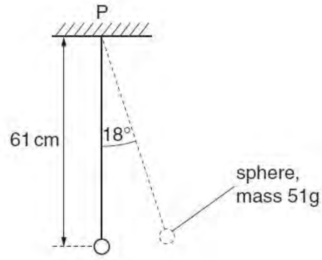

Fig. 3.1
The sphere is moved to one side, keeping the string taut, so that the string makes an angle of 18° with the vertical. Calculate
(i) the gain in gravitational potential energy of the sphere,
gain = ………………………. J [2]
(ii) the moment of the weight of the sphere about point P.
moment = ... N m [2]

11. May 08-Q/3
A shopping trolley and its contents have a total mass of 42 kg. The trolley is being pushed along a horizontal surface at a speed of 1.2 m s^{-1}. When the trolley is released, it travels a distance of 1.9 m before coming to rest.
(a) Assuming that the total force opposing the motion of the trolley is constant,
(i) calculate the deceleration of the trolley,
deceleration = ... m s^{-2} [2]
(ii) show that the total force opposing the motion of the trolley is 16 N. [1]
(b) Using the answer in (a)(ii), calculate the power required to overcome the total force opposing the motion of the trolley at a speed of 1.2 m s^{-1}. power = ... W [2]