1 The conservation of energy is an important principle that features in all branches of Physics. Discuss how energy is conserved in the following scenarios.

(a) When water in an electric kettle is boiling, the temperature of the water remains the same.

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....[3]

(b) When coherent light passes through a thin slit and falls onto a screen, the centre of the screen has intensity I. When the light passes through two slits in a similar setup, the intensity at the centre of the screen becomes approximately $4I$.

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....[3]

[Total: 6]

2 **(a)** A block of mass 0.40 kg slides in a straight line with a constant speed of 0.30 m s^{-1} along a horizontal surface, as shown in Fig. 3.1.

Fig. 3.1

The block hits a spring and decelerates. The speed of the block becomes zero when the spring is compressed by 8.0 cm.

(i) Calculate the initial kinetic energy of the block.

kinetic energy = ……………………J [1]

(ii) The variation of the compression *x* of the spring with the force *F* applied to the spring is shown in Fig. 3.2.

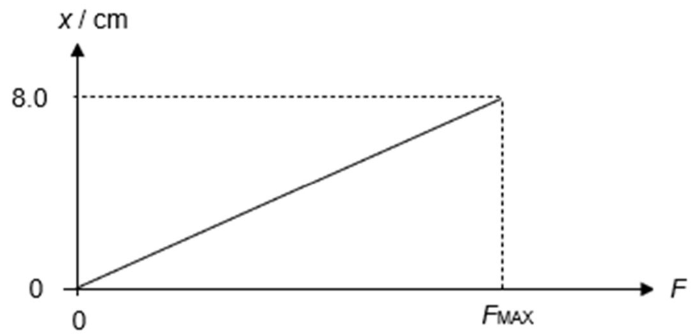


Fig. 3.2

2 Use your answer in **(a)(i)** to determine the maximum force F_{MAX} exerted on the spring by the block. Explain your working.

F_{MAX} = …………………… N [3]

(iii) Calculate the maximum deceleration of the block.

deceleration = …………………… m s^{-2} [1]

(iv) State and explain whether the block is in equilibrium

1. before it hits the spring,

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

2. when its speed becomes zero.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(b) The mass m of the block in **(a)** is now varied. The initial speed of the block remains constant and the spring continues to obey Hooke's law.

On Fig. 3.3, sketch the variation of the maximum compression x_0 of the spring with the mass m.

Fig. 3.3

[2]

3 **(a)** A force F is acting on a body of mass m that causes it to move with a velocity v. Given that the body started from rest, show that the kinetic energy E_k of the body is given by

$$E_k = \frac{1}{2}mv^2$$

[3]

(b) Fig. 4.1 below shows a vertical semi-circular path which has a radius of 2.0 m centred at **O**. A point object of mass 3.0 kg is released from rest at **P**. The path exerts a constant frictional force on the object and it reaches point **Q** where it comes to rest momentarily. The angular displacement between **P** and **Q** with respect to **O** is 145°.

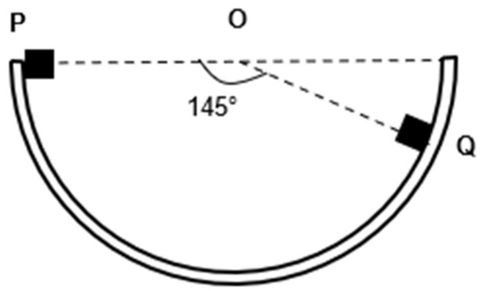


Fig. 4.1

(i) Calculate the frictional force exerted by the track on the object.

frictional force =..N [3]

(ii) Calculate the kinetic energy of the object at the lowest point on the track.

kinetic energy =..J [2]

3 Fig. 3.1 shows a block of mass 0.30 kg released from rest at a height of 0.10 m above a light spring of force constant 80 N m^{-1}. The block lands on the light board and compresses the spring before rebounding.

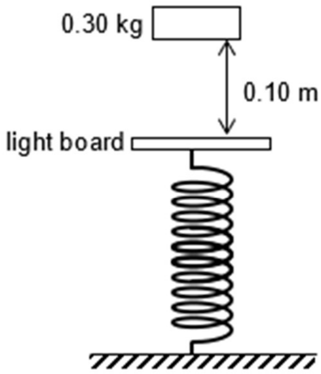


Fig. 3.1

(a) Calculate the maximum compression of the spring.

maximum compression = …………………… m [2]

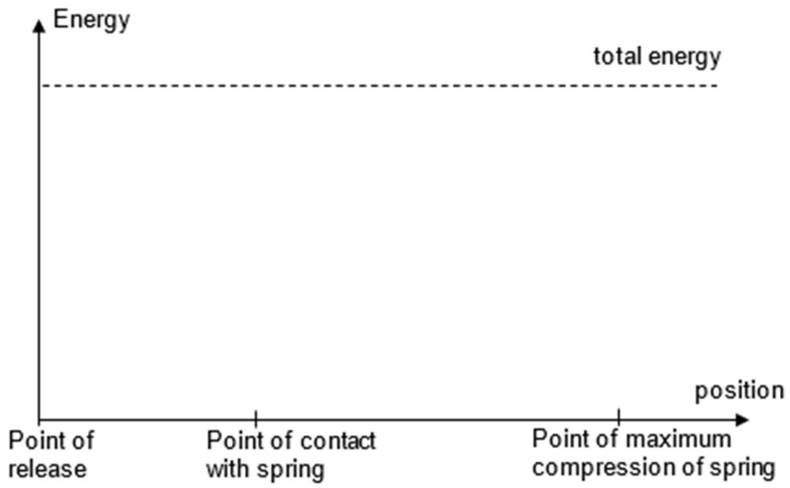
(b) Determine the maximum kinetic energy attained by the block before it comes to a momentary stop.

maximum kinetic energy = ………………………. J [3]

3 **(c)** On Fig. 3.2 below, sketch the graphs of kinetic energy (label this KE), gravitational potential energy (label this GPE) and elastic potential energy (label this EPE) with respect to position of the mass.

Take the gravitational potential energy at the maximum compression to be zero.

There is no need to indicate numerical values.



[3]

Fig. 3.2

[Total: 8]

4 A 2.0 kg block on a track is released at A, 1.0 m above the ground as shown in Fig. 3.1. The track is frictionless except for the rough surface between B and C, which has a length of 2.0 m. The block travels down the track, hits the spring of force constant k = 225 N m^{-1} at D and compresses the spring by 0.20 m from its equilibrium position before coming to rest momentarily.

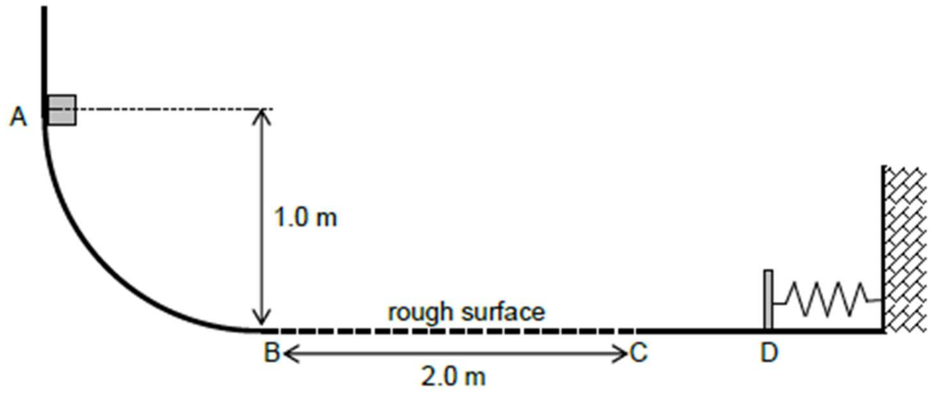


Fig. 3.1

(a) **(i)** Determine the speed of the block at B.

speed at B = ... m s^{-1} [2]

(ii) Calculate the maximum elastic potential energy stored in the spring.

elastic potential energy = ... J [1]

(iii) Using your answers to **(a)(i)** and **(ii)**, determine the work done against friction when the block travels from B to C.

work done against friction = ... J [2]

4 **(b)** The block subsequently rebounds and moves towards B after the spring un-compresses itself. Determine the distance along the track from C where the block finally stops.

distance from C = ……………….. m [3]

[Total: 8]

5 Fig. 3.1 shows a wind turbine with a diameter of 100 m. Wind of density 1.2 kg m^{-3} is incident normally on the blades of the turbine at a speed of 20 m s^{-1}.

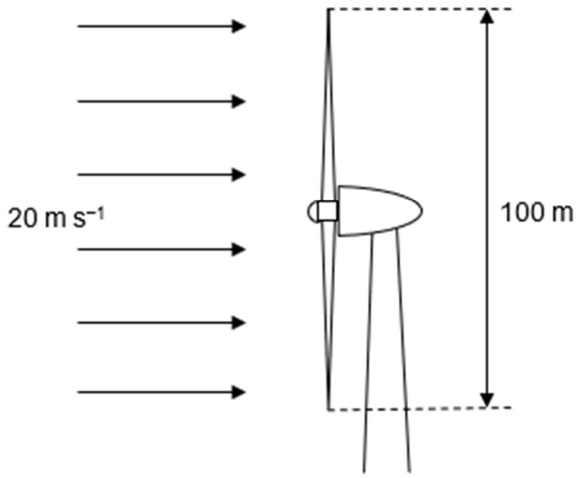


Fig. 3.1

(a) Calculate the volume of air that passes through the area swept out by the turbine blades in one second.

volume = ... m^3 [2]

(b) Hence, calculate the mass of air that passes through the area swept out by the turbine blades in one second.

mass = ... kg [1]

5 **(c)** After passing through the blades, the wind speed decreases to 15 m s^{-1}.

(i) Determine the rate of loss of kinetic energy of the wind.

rate of loss of kinetic energy = ... W [2]

(ii) Using Newton's second law, determine the force exerted by the turbine blades on the wind.

force = ... N [2]

(d) Explain how the answers obtained in **(c)(i)** and **(c)(ii)** are related by the equation $P = Fv$.

....

.... [1]

6 **(a)** State what is meant by *work done* on a body.

....

.... [1]

(b) A system of two bodies A and B are connected by an inextensible cord over a frictionless pulley and are resting on inclined planes as shown in Fig 3.1. Body A of mass 2.00 kg and body B of mass 5.00 kg move in the directions as indicated, by a distance of 0.500 m each and experiences frictional force of 3.00 N and 5.00 N respectively.

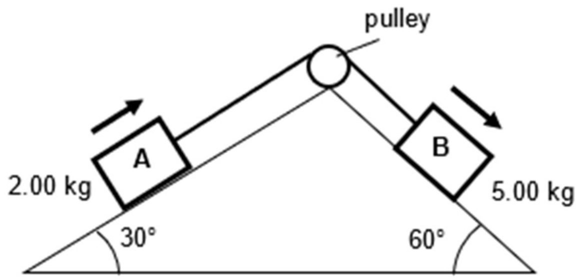


Fig 3.1

(i) Calculate the total work done against the frictional forces.

work done = ... J [1]

(ii) Determine the final speed of the system after travelling 0.500 m.

final speed = m s^{-1} [3]

6 **(iii)** If this experiment is conducted in a laboratory in the moon where the acceleration due to gravity, g is reduced to 20%, deduce and explain if the two bodies will still move. Assuming the maximum frictional forces have the same values as given in (b).

....

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.... [2]

[Total: 7]

7

(a) A children's outdoor paddling pool is 4.0 m in diameter and 20.0 cm deep. Cold water is allowed to flow in to one side of the pool at a rate of 20 litres per minute, and the same amount of water overflows from the other side of the pool (1 litre = 1kg of water). The water in the pool mixes evenly so that it is all heated by the energy from the sun.

On a good sunny day, the sun provides energy to raise the temperature of the water between entering and leaving the pool. The temperature rise is 3.0 K.

(i) Given that the specific heat capacity of water is 4200 J kg^{-1} K^{-1}, show that the energy from the sun received by the 20 litres of water, between entering and leaving the pool, in one minute, is 252 kJ. [1]

(ii) Hence, calculate the solar power per square metre falling on the surface of the pool.

Power per square meter = ...W m^{-2} [2]

(iii) Suggest why the value calculated in **(a)(ii)** is likely to be too low.

....

....[1]

(b) An electrical (photovoltaic) solar cell (see **Fig. 6.2**)is connected in a simple circuit, as shown in **Fig. 6.1**. The solar cell is placed in the **same** sunlight as in (a). A solar cell, or photovoltaic cell, is a device that converts light energy directly into electrical energy. It produces a voltage when exposed to light.

7

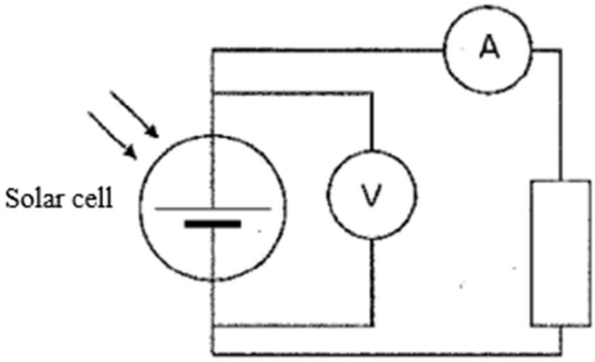

Fig. 6.1

Fig. 6.2

The following information is available:
Dimensions of solar cell = 15 cm x 15 cm
Current in circuit = 200 mA
Voltage across solar cell = 7.0 V

(i) Calculate the power per square metre generated by the solar cell.

Power per square metre = ... W m^{-2} [1]

(ii) Assuming that the value for the solar power per square metre, calculated in **(a)(ii),** is the correct value, calculate the efficiency of the solar cell.

Efficiency = ... %[1]

(c) (i) Above the atmosphere, the intensity (I) of the solar radiation is about 1.4 kW m^{-2}. Given that the distance from the Sun to the Earth is $r = 150 \times 10^6$ km, calculate the power output of the sun.

Power output = ... W[2]

7

(ii) Assuming that the electrical solar panels of a satellite in orbit around the Earth are 40% efficient, calculate the surface area of the solar panels required to produce an electrical output power of 200 W.

Surface area = ………………… m^2[2]

8 A 2.0 kg box on a frictionless incline of angle 40° is connected by a cord that runs over a massless and frictionless pulley to a light spring of spring constant $k = 120$ N m^{-1}, as shown in **Fig. 1.1**. The box is released from rest along the inclined plane when the spring is unstretched.

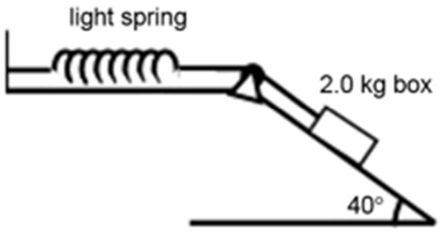

Fig. 1.1

(a) Calculate the energy stored in the spring when the box reaches 10 cm down the incline.

Energy stored = ……………………. J [2]

(b) Determine, D, the distance along the incline moved through by the box before it comes to a stop.

D = ……………………. m [2]

(c) State what will happen to the answer calculated in **(b)** if the inclined angle is increased.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

8

(d) The frictionless incline is now replaced by a rough incline. Assuming the average friction between the rough incline and the box is 5.0 N, determine D', the new distance moved through by the box before it comes to a stop.

D' = ………………………… m [2]

(e) Explain qualitatively how D' might change if a spring with a bigger spring constant were used instead.

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