## Questions on Work & Energy

**1.** Describe one example where elastic potential energy is stored.

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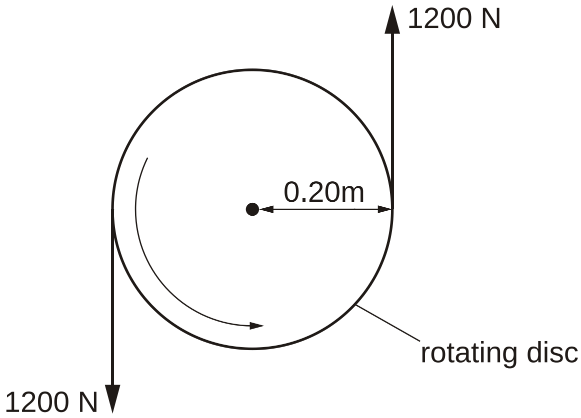
[Total 1 mark]

**2.** The figure below shows two forces, each of magnitude 1200 N, acting on the edge of a disc of radius 0.20 m.




(a) (i) Define the *torque of a couple.*

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[1]

(ii) Calculate the torque produced by these forces.

torque = ............................N m

[2]

(b) This torque is needed to overcome friction and keep the disc rotating at a constant rate.

(i) Show that the work done by the **two** forces when the disc rotates one complete revolution is about 3000 J.

[2]

(ii) Calculate the power required to keep the disc rotating at 40 revolutions per second.

power = .............................. W

[2]

[Total 7 marks]

**3.** Fig. 1 shows part of the force-extension graph for a spring. The spring obeys Hooke's law for forces up to 5.0 N.

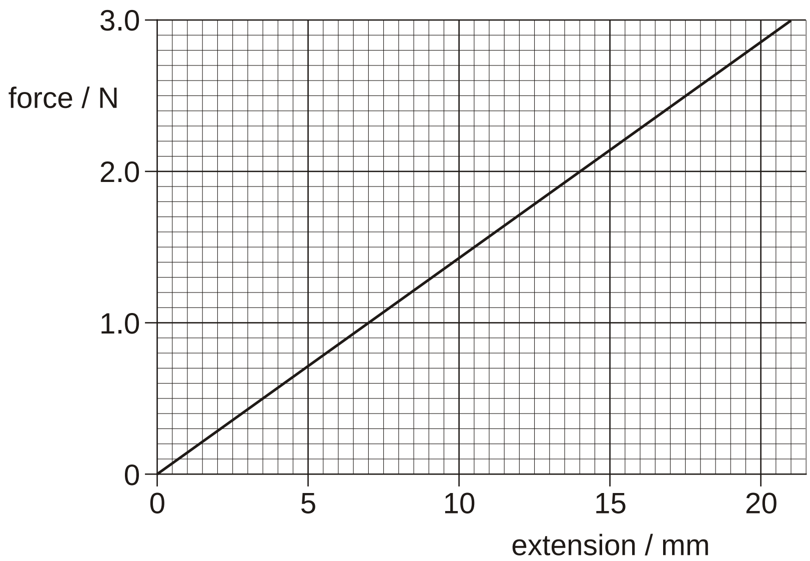


**Fig. 1**

(a) Calculate the extension produced by a force of 5.0 N.

extension = ............................ mm

[2]

(b) Fig. 2 shows a second identical spring that has been put in parallel with the first spring. A force of 5.0 N is applied to this combination of springs.

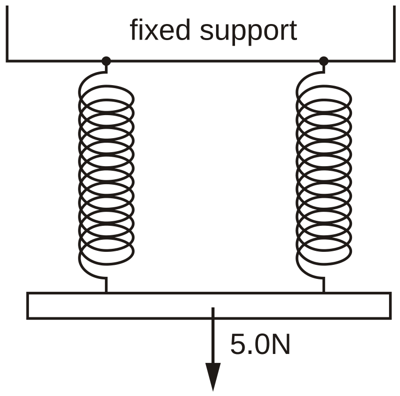


**Fig. 2**

For the arrangement shown in Fig. 2, calculate

(i) the extension of each spring

extension = ............................ mm

[2]

(ii) the total strain energy stored in the springs.

strain energy = ................................ J

[2]

(c) The Young modulus of the wire used in the springs is $2.0 \times 10^{11}$ Pa. Each spring is made from a straight wire of length 0.40 m and cross-sectional area $2.0 \times 10^{-7}$ $m^2$. Calculate the extension produced when a force of 5.0 N is applied to this straight wire.

extension = ...............................m

[3]

(d) Describe and explain, without further calculations, the difference in the strain energies stored in the straight wire and in the spring when a 5.0 N force is applied to each.

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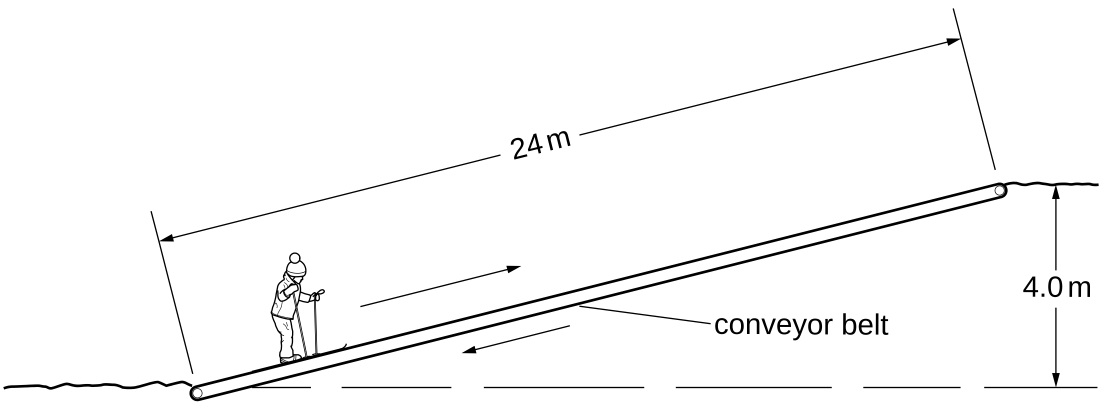
[2]

[Total 11 marks]

**4.** The figure below illustrates a conveyor belt for transporting young children up a snow-covered bank so that they can ski back down.




A child of mass 20 kg travels up the conveyor belt at a constant speed. The distance travelled up the slope is 24 m and the time taken is 55 s. The vertical height climbed in this time is 4.0 m.

(a) For the child on the conveyor belt, calculate

(i) her speed

speed = ............................ m $s^{-1}$

[2]

(ii) her kinetic energy

kinetic energy = ............................ J

[2]

(iii) the increase in her potential energy for the complete journey up the slope.

potential energy = ............................ J

[2]

(b) (i) The conveyor belt is designed to take a maximum of 15 children at any one time. Calculate the power needed to lift 15 children of average mass 20 kg through a height of 4.0 m in 55 s.

power = ............................ W

[2]

(ii) The belt is driven by an electric motor. State **two** reasons why the motor needs a greater output power than that calculated in **(b)(i)**.

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[2]

[Total 10 marks]

**5.** State the principle of conservation of energy.

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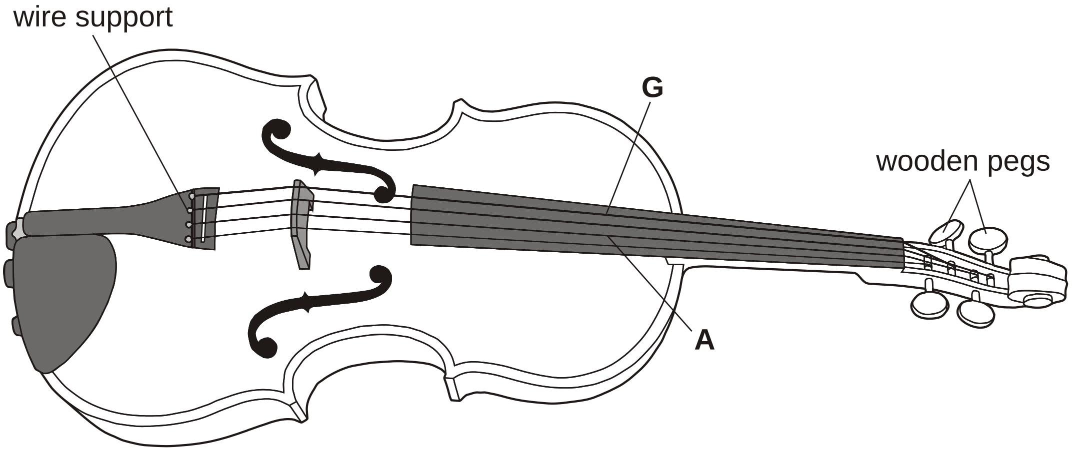
[Total 1 mark]

**6.** The figure below shows a violin.




Two of the wires used on the violin, labelled **A** and **G** are made of steel. The two wires are both 500 mm long between the pegs and support. The 500 mm length of wire labelled **G** has a mass of $2.0 \times 10^{-3}$ kg. The density of steel is $7.8 \times 10^{3}$ kg m $^{-3}$.

(i) Show that the cross-sectional area of wire **G** is $5.1 \times 10^{-7}$ m$^2$.

[2]

(ii) The wires are put under tension by turning the wooden pegs shown in the figure. The Young modulus of steel is $2.0 \times 10^{11}$ Pa. Calculate the tension required in wire **G** to produce an extension of $4.0 \times 10^{-4}$ m.

tension = ................................N

[3]

(iii) Wire **A** has a diameter that is half that of wire **G**. Determine the tension required for wire **A** to produce an extension of $16 \times 10^{-4}$ m.

tension = ................................N

[1]

(iv) State the law that has been assumed in the calculations in **(ii)** and **(iii)**.

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[1]

[Total 7 marks]

**7.** The results given in the table below are obtained in an experiment to determine the Young modulus of a metal in the form of a wire. The wire is loaded in steps of 5.0 N up to 25.0 N and then unloaded.

| | loading | unloading |
|---|---|---|
| load / N | extension / mm | extension /mm |
| 0.0 | 0.00 | 0.00 |
| 5.0 | 0.24 | 0.24 |
| 10.0 | 0.47 | 0.48 |
| 15.0 | 0.71 | 0.71 |
| 20.0 | 0.96 | 0.95 |
| 25.0 | 1.20 | 1.20 |

(i) Using the results in the table and without plotting a graph, state and explain whether the deformation of the wire

**1** is plastic or elastic

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[1]

**2** obeys Hooke's law.

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[2]

(ii) Explain how the extension and length of the wire may be determined experimentally.

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[2]

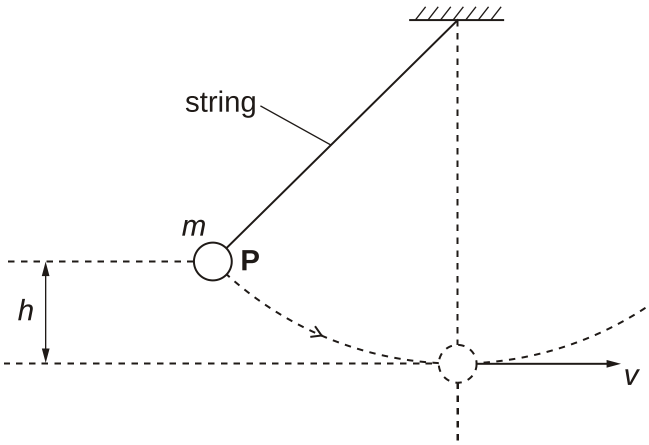
(iii) The wire tested is 1.72 m long and has a cross-sectional area of $1.80 \times 10^{-7}$ m$^2$. Use the extension value given in the table for a load of 25.0 N to calculate the Young modulus of the metal of the wire.

Young modulus = ............................. Pa

[3]

[Total 8 marks]

**8.** The figure below shows a simple pendulum with a metal ball attached to the end of a string.




When the ball is released from **P**, it describes a circular path. The ball has a maximum speed *v* at the bottom of its swing. The vertical distance between **P** and bottom of the swing is *h*. The mass of the ball is *m*.

(i) Write the equations for the change in gravitational potential energy, $E_p$, of the ball as it drops through the height *h* and for the kinetic energy, $E_k$, of the ball at the bottom of its swing when travelling at speed *v*.

$E_p$ =

$E_k$ =

[1]

(ii) Use the principle of conservation of energy to derive an equation for the speed *v*. Assume that there are no energy losses due to air resistance.

[2]

[Total 3 marks]

**9.** Some countries in the world have frequent thunderstorms. A group of scientists plan to use the energy from the falling rain to generate electricity. A typical thunderstorm deposits rain to a depth of $1.2 \times 10^{-2}$ m over a surface area of $2.0 \times 10^{7}$ $m^2$ during a time of 900 s. The rain falls from an average height of $2.5 \times 10^{3}$ m. The density of rainwater is $1.0 \times 10^{3}$ kg $m^{-3}$. About 30% of the gravitational potential energy of the rain can be converted into electrical energy at the ground.

(i) Show that the total mass of water deposited in 900 s is $2.4 \times 10^{8}$ kg.

[2]

(ii) Hence show that the average electrical power available from this thunderstorm is about 2 GW.

[3]

(iii) Suggest one problem with this scheme of energy production.

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[1]

[Total 6 marks]

**10.** The force against length graph for a spring is shown in Fig. 1.

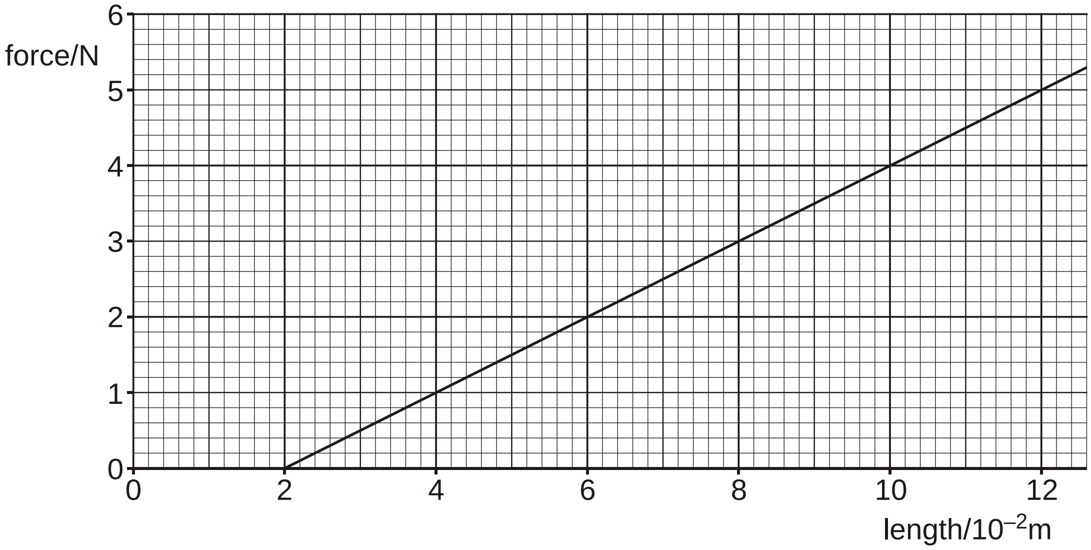


**Fig. 1**

(a) Explain why the graph does not pass through the origin.

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[1]

(b) State what feature of the graph shows that the spring obeys Hooke's law.

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[1]

(c) The gradient of the graph is equal to the force constant *k* of the spring. Determine the force constant of the spring.

force constant = ............................................... N $m^{-1}$

[2]

(d) Calculate the work done on the spring when its length is increased from $2.0 \times 10^{-2}$ m to $8.0 \times 10^{-2}$ m.

work done = ...................................................... J

[2]

(e) One end of the spring is fixed and a mass is hung vertically from the other end. The mass is pulled down and then released. The mass oscillates up and down. Fig. 2 shows the displacement *s* against time *t* graph for the mass.

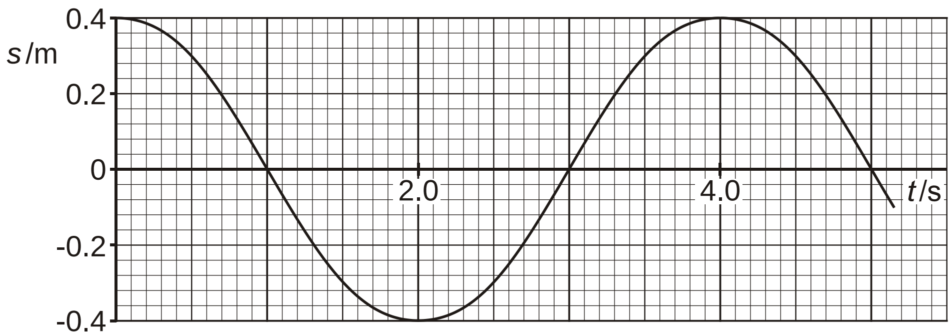


**Fig. 2**

Explain how you can use Fig. 2 to determine the **maximum** speed of the mass. You are not expected to do the calculations.

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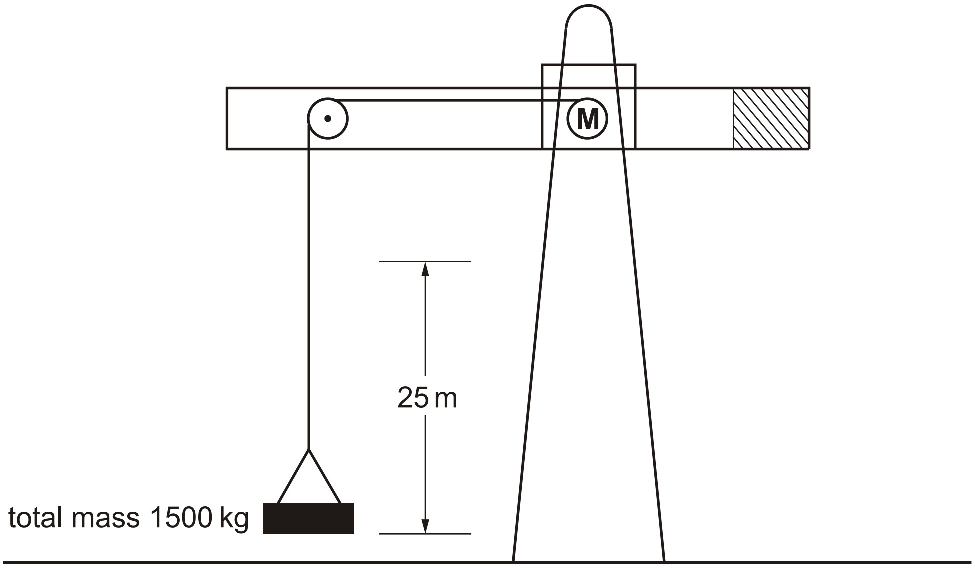
[2]

[Total 8 marks]

**11.** The figure below shows a crane that is used to move heavy objects.




The motor **M** in the crane lifts a total mass of 1500 kg through a height of 25 m at a constant velocity of 1.6 m $s^{-1}$.

Calculate

(i) the tension in the lifting cable

tension = ............................. N

[2]

(ii) the time taken for the mass to be raised through the height of 25 m

time = ............................. s

[1]

(iii) the rate of gain of potential energy of the mass

rate of gain of potential energy = ............................. J $s^{-1}$

[3]

(iv) the minimum output power of the motor used to raise the mass.

power = .............................. W

[1]

[Total 7 marks]

**12.** (a) Define *the Young modulus* of a material.

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[1]

(b) Explain why the quantity strain has no units.

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[1]

[Total 2 marks]