AQA Maths M2

Topic Questions from Papers

Energy, Work and Power

1 A car has a maximum speed of $42\ \mathrm{m\,s^{-1}}$ when it is moving on a horizontal road. When the speed of the car is $v\ \mathrm{m\,s^{-1}}$, it experiences a resistance force of magnitude $30v$ newtons.

(a) Show that the maximum power of the car is 52 920 W. *(2 marks)*

(b) The car has mass 1200 kg. It travels, from rest, up a slope inclined at 5° to the horizontal.

(i) Show that, when the car is travelling at its maximum speed $V\ \mathrm{m\,s^{-1}}$ up the slope,

$$V^2 + 392\sin 5°\,V - 1764 = 0$$ *(4 marks)*

(ii) Hence find V. *(2 marks)*

(Q4, Jan 2006)

2 A particle, of mass 10 kg, is attached to one end of a light elastic string of natural length 0.4 metres and modulus of elasticity 100 N. The other end of the string is fixed to the point O.

(a) Find the length of the elastic string when the particle hangs in equilibrium directly below O. *(2 marks)*

(b) The particle is pulled down and held at a point P, which is 1 metre vertically below O.

Show that the elastic potential energy of the string when the particle is in this position is 45 J. *(2 marks)*

(c) The particle is released from rest at the point P. In the subsequent motion, the particle has speed $v\ \mathrm{m\,s^{-1}}$ when it is x metres **below** $\boldsymbol{O}$.

(i) Show that, while the string is taut,

$$v^2 = 39.6x - 25x^2 - 14.6$$ *(7 marks)*

(ii) Find the value of x when the particle comes to rest for the first time after being released, given that the string is still taut. *(3 marks)*

(Q7, Jan 2006)

3 A block of mass 2 kg is placed on a horizontal surface. An elastic string has natural length 0.5 metres and modulus of elasticity 30 newtons. One end of the string is fixed to the surface at the point O and the other end is attached to the block. The block is pulled along the surface away from O until it is at the point P, where the length of OP is 1.8 metres. The block can be modelled as a particle.

(a) Calculate the elastic potential energy in the string when the block is at P. *(2 marks)*

(b) Assume that the horizontal surface is smooth.

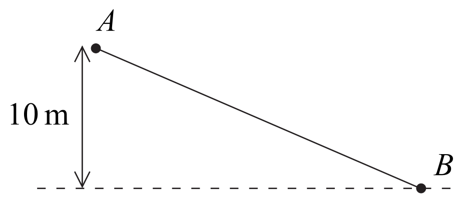
(i) The block is then released from P and moves towards O. Show that, when the block has moved 0.5 metres, its speed is 5.61 m s^{-1}, correct to three significant figures. *(5 marks)*

(ii) Find the speed of the block when it reaches O. *(3 marks)*

(c) Assume that the horizontal surface is rough and that the coefficient of friction between the surface and the block is 0.1. Find the speed of the block when it reaches O. *(5 marks)*

(Q3, June 2006)

4 A child, of mass 35 kg, slides down a slide in a water park. The child, starting from rest, slides from the point A to the point B, which is 10 metres vertically below the level of A, as shown in the diagram.



(a) In a simple model, all resistance forces are ignored.

Use an energy method to find the speed of the child at B. *(3 marks)*

(b) State one resistance force that has been ignored in answering part (a). *(1 mark)*

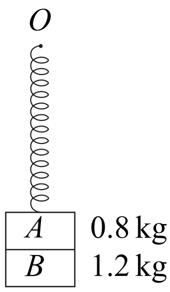
(c) In fact, when the child slides down the slide, she reaches B with a speed of 12 m s^{-1}.

Given that the slide is 20 metres long and the sum of the resistance forces has a constant magnitude of F newtons, use an energy method to find the value of F. *(4 marks)*

(Q1, Jan 2007)

5 Two small blocks, A and B, of masses 0.8 kg and 1.2 kg respectively, are stuck together. A spring has natural length 0.5 metres and modulus of elasticity 49 N. One end of the spring is attached to the top of the block A and the other end of the spring is attached to a fixed point O.

(a) The system hangs in equilibrium with the blocks stuck together, as shown in the diagram.



Find the extension of the spring. *(3 marks)*

(b) Show that the elastic potential energy of the spring when the system is in equilibrium is 1.96 J. *(2 marks)*

(c) The system is hanging in this equilibrium position when block B falls off and block A begins to move vertically upwards.

Block A next comes to rest when the spring is **compressed** by x metres.

(i) Show that x satisfies the equation

$$x^2 + 0.16x - 0.008 = 0$$ *(5 marks)*

(ii) Find the value of x. *(2 marks)*

(Q8, Jan 2007)

6 A hot air balloon moves vertically upwards with a constant velocity. When the balloon is at a height of 30 metres above ground level, a box of mass 5 kg is released from the balloon.

After the box is released, it initially moves vertically upwards with speed $10\,\mathrm{m\,s^{-1}}$.

(a) Find the initial kinetic energy of the box. *(2 marks)*

(b) Show that the kinetic energy of the box when it hits the ground is 1720 J. *(3 marks)*

(c) Hence find the speed of the box when it hits the ground. *(3 marks)*

(d) State **two** modelling assumptions which you have made. *(2 marks)*

(Q1, June 2007)

7 An elastic string has one end attached to a point O, fixed on a horizontal table. The other end of the string is attached to a particle of mass 5 kilograms. The elastic string has natural length 2 metres and modulus of elasticity 200 newtons. The particle is pulled so that it is 2.5 metres from the point O and it is then released from rest on the table.

(a) Calculate the elastic potential energy when the particle is 2.5 m from the point O. *(2 marks)*

(b) If the table is smooth, show that the speed of the particle when the string becomes slack is $\sqrt{5}\text{ m s}^{-1}$. *(3 marks)*

(c) The table is, in fact, rough and the coefficient of friction between the particle and the table is 0.4.

Find the speed of the particle when the string becomes slack. *(7 marks)*

(Q6, June 2007)

8 A ball is thrown vertically upwards from ground level with an initial speed of 15 m s^{-1}. The ball has a mass of 0.6 kg. Assume that the only force acting on the ball after it is thrown is its weight.

(a) Calculate the initial kinetic energy of the ball. *(2 marks)*

(b) By using conservation of energy, find the maximum height above ground level reached by the ball. *(3 marks)*

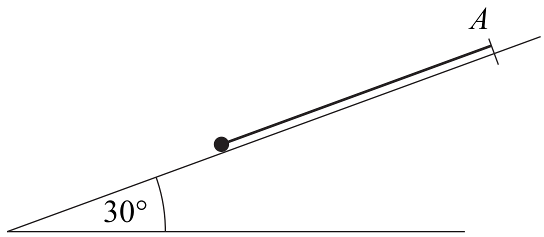
(c) By using conservation of energy, find the kinetic energy and the speed of the ball when it is at a height of 3 m above ground level. *(4 marks)*

(d) State one modelling assumption which has been made. *(1 mark)*

(Q1, Jan 2008)

9 A light elastic string has one end attached to a point A fixed on a smooth plane inclined at $30°$ to the horizontal. The other end of the string is attached to a particle of mass 6 kg. The elastic string has natural length 4 metres and modulus of elasticity 300 newtons.

The particle is pulled down the plane in the direction of the line of greatest slope through A. The particle is released from rest when it is 5.5 metres from A.



(a) Calculate the elastic potential energy of the string when the particle is 5.5 metres from the point A. *(2 marks)*

(b) Show that the speed of the particle when the string becomes slack is $3.66\,\mathrm{m\,s^{-1}}$, correct to three significant figures. *(5 marks)*

(c) Show that the particle will **not** reach point A in the subsequent motion. *(3 marks)*

(Q6, Jan 2008)

10 A van, of mass 1500 kg, has a maximum speed of $50\,\mathrm{m\,s^{-1}}$ on a straight horizontal road. When the van travels at a speed of $v\,\mathrm{m\,s^{-1}}$, it experiences a resistance force of magnitude $40v$ newtons.

(a) Show that the maximum power of the van is 100 000 watts. *(2 marks)*

(b) The van is travelling along a straight horizontal road.

Find the maximum possible acceleration of the van when its speed is $25\,\mathrm{m\,s^{-1}}$. *(3 marks)*

(c) The van starts to climb a hill which is inclined at $6°$ to the horizontal. Find the maximum possible constant speed of the van as it travels in a straight line up the hill. *(6 marks)*

(Q4, June 2008)

11 (a) Hooke's law states that the tension in a stretched string of natural length l and modulus of elasticity λ is $\frac{\lambda x}{l}$ when its extension is x.

Using this formula, prove that the work done in stretching a string from an unstretched position to a position in which its extension is e is $\frac{\lambda e^2}{2l}$. *(3 marks)*

(b) A particle, of mass 5 kg, is attached to one end of a light elastic string of natural length 0.6 metres and modulus of elasticity 150 N. The other end of the string is fixed to a point O.

(i) Find the extension of the elastic string when the particle hangs in equilibrium directly below O. *(2 marks)*

(ii) The particle is pulled down and held at the point P, which is 0.9 metres vertically below O.

Show that the elastic potential energy of the string when the particle is in this position is 11.25 J. *(2 marks)*

(iii) The particle is released from rest at the point P. In the subsequent motion, the particle has speed $v\,\mathrm{m\,s^{-1}}$ when it is x metres **above *P***.

Show that, while the string is taut,

$$v^2 = 10.4x - 50x^2$$ *(7 marks)*

(iv) Find the value of x when the particle comes to rest for the first time after being released, given that the string is still taut. *(2 marks)*

(Q8, June 2008)

12 A stone, of mass 6 kg, is thrown vertically upwards with a speed of $12\,\mathrm{m\,s^{-1}}$ from a point at a height of 4 metres above ground level.

(a) Calculate the initial kinetic energy of the stone. *(2 marks)*

(b) (i) Show that the kinetic energy of the stone when it hits the ground is 667 J, correct to three significant figures. *(2 marks)*

(ii) Hence find the speed of the stone when it hits the ground. *(3 marks)*

(iii) State two modelling assumptions that you have made. *(2 marks)*

(Q2, Jan 2009)

13 A train, of mass 60 tonnes, travels on a straight horizontal track. It has a maximum speed of $40\,\mathrm{m\,s^{-1}}$ when its engine is working at $800\,\mathrm{kW}$.

(a) Find the magnitude of the resistance force acting on the train when the train is travelling at its maximum speed. *(3 marks)*

(b) When the train is travelling at $40\,\mathrm{m\,s^{-1}}$, the power is turned off. Assume that the resistance force is constant and is equal to that found in part (a). Also assume that this resistance force is the only horizontal force acting on the train.

Use an energy method to find how far the train travels when slowing from $40\,\mathrm{m\,s^{-1}}$ to $36\,\mathrm{m\,s^{-1}}$. *(4 marks)*

(Q6, Jan 2009)

14 A bungee jumper, of mass 80 kg, is attached to one end of a light elastic cord, of natural length 16 metres and modulus of elasticity 784 N. The other end of the cord is attached to a horizontal platform, which is at a height of 65 metres above the ground.

The bungee jumper steps off the platform at the point where the cord is attached and falls vertically. The bungee jumper can be modelled as a particle. Hooke's law can be assumed to apply throughout the motion and air resistance can be assumed to be negligible.

(a) Find the length of the cord when the acceleration of the bungee jumper is zero. *(3 marks)*

(b) The cord extends by x metres beyond its natural length before the bungee jumper first comes to rest.

(i) Show that $x^2 - 32x - 512 = 0$. *(4 marks)*

(ii) Find the distance above the ground at which the bungee jumper first comes to rest. *(4 marks)*

(Q9, Jan 2009)

15 A slide at a water park may be modelled as a smooth plane of length 20 metres inclined at $30°$ to the vertical. Anne, who has a mass of 55 kg, slides down the slide. At the top of the slide, she has an initial velocity of $3\,\mathrm{m\,s^{-1}}$ down the slide.

(a) Calculate Anne's initial kinetic energy. *(2 marks)*

(b) By using conservation of energy, find the kinetic energy and the speed of Anne after she has travelled the 20 metres. *(6 marks)*

(c) State one modelling assumption which you have made. *(1 mark)*

(Q2, June 2009)

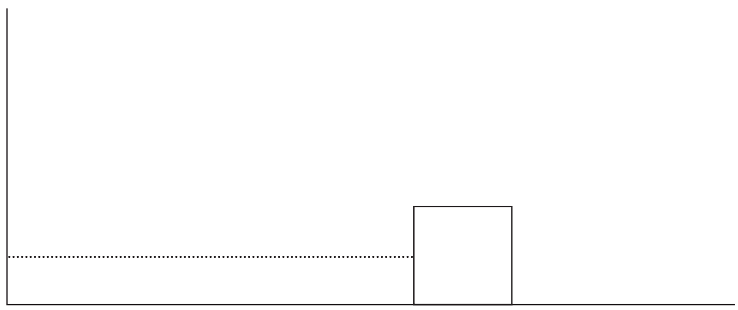
16 A train, of mass 600 tonnes, travels at constant speed up a slope inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{40}$. The speed of the train is $24\,\text{m s}^{-1}$ and it experiences total resistance forces of 200 000 N.

Find the power produced by the train, giving your answer in kilowatts. *(6 marks)*

(Q5, June 2009)

17 A block, of mass 5 kg, is attached to one end of a length of elastic string. The other end of the string is fixed to a vertical wall. The block is placed on a horizontal surface.

The elastic string has natural length 1.2 m and modulus of elasticity 180 N. The block is pulled so that it is 2 m from the wall and is then released from rest. Whilst taut, the string remains horizontal. It may be assumed that, after the string becomes slack, it does not interfere with the movement of the block.



(a) Calculate the elastic potential energy when the block is 2 m from the wall. *(2 marks)*

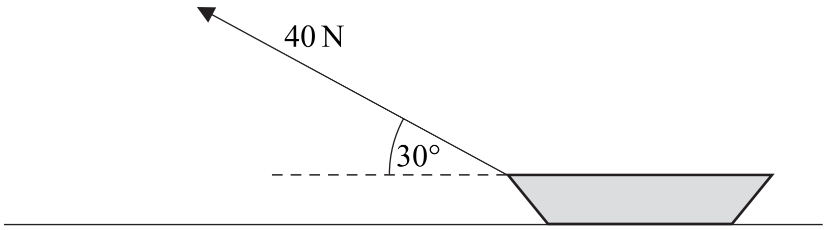
(b) If the horizontal surface is smooth, find the speed of the block when it hits the wall. *(3 marks)*

(c) The surface is in fact rough and the coefficient of friction between the block and the surface is μ.

Find μ if the block comes to rest just as it reaches the wall. *(7 marks)*

(Q6, June 2009)

18 An inextensible rope is attached to a sledge which is at rest on a horizontal surface. A constant force of magnitude 40 newtons at an angle of 30° to the horizontal is applied to the sledge, as shown in the diagram.



Calculate the work done by the force as the sledge is moved 5 metres along the surface.

(3 marks)

(Q1, Jan 2010)

19 A bungee jumper, of mass 49 kg, is attached to one end of a light elastic cord of natural length 22 metres and modulus of elasticity 1078 newtons. The other end of the cord is attached to a horizontal platform, which is at a height of 60 metres above the ground.

The bungee jumper steps off the platform at the point where the cord is attached, and falls vertically. The bungee jumper can be modelled as a particle. Assume that Hooke's Law applies whilst the cord is taut and that air resistance is negligible throughout the motion.

When the bungee jumper has fallen x metres, his speed is $v\,\text{m}\,\text{s}^{-1}$.

(a) By considering energy, show that, when x is greater than 22,

$$5v^2 = 318x - 5x^2 - 2420$$ *(6 marks)*

(b) Explain why x must be greater than 22 for the equation in part (a) to be valid. *(1 mark)*

(c) Find the maximum value of x. *(4 marks)*

(d) (i) Show that the speed of the bungee jumper is a maximum when $x = 31.8$.

(3 marks)

(ii) Hence find the maximum speed of the bungee jumper. *(2 marks)*

(Q8, Jan 2010)

20 John is at the top of a cliff, looking out over the sea. He throws a rock, of mass 3 kg, horizontally with a velocity of $4\,\mathrm{m\,s^{-1}}$.

The rock falls a vertical distance of 51 metres to reach the surface of the sea.

(a) Calculate the kinetic energy of the rock when it is thrown. *(2 marks)*

(b) Calculate the potential energy lost by the rock when it reaches the surface of the sea. *(2 marks)*

(c) (i) Find the kinetic energy of the rock when it reaches the surface of the sea.

(ii) Hence find the speed of the rock when it reaches the surface of the sea. *(4 marks)*

(d) State one modelling assumption which has been made. *(1 mark)*

(Q2, June 2010)

21 When a car, of mass 1200 kg, travels at a speed of $v\,\mathrm{m\,s^{-1}}$, it experiences a resistance force of magnitude $30v$ newtons.

The car has a maximum constant speed of $48\,\mathrm{m\,s^{-1}}$ on a straight horizontal road.

(a) Show that the maximum power of the car is 69 120 watts. *(2 marks)*

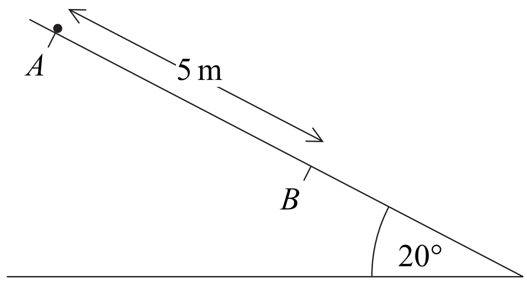
(b) The car is travelling along a straight horizontal road.

Find the maximum possible acceleration of the car when it is travelling at a speed of $40\,\mathrm{m\,s^{-1}}$. *(4 marks)*

(c) The car starts to descend a hill on a straight road which is inclined at an angle of 3° to the horizontal. Find the maximum possible constant speed of the car as it travels on this road down the hill. *(7 marks)*

(Q6, June 2010)

22 A particle is placed on a smooth plane which is inclined at an angle of 20° to the horizontal. The particle, of mass 4 kg, is released from rest at a point A and travels down the plane, passing through a point B. The distance AB is 5 m.



(a) Find the potential energy lost as the particle moves from point A to point B. *(2 marks)*

(b) Hence write down the kinetic energy of the particle when it reaches point B. *(1 mark)*

(c) Hence find the speed of the particle when it reaches point B. *(2 marks)*

(Q2, Jan 2011)

23 A pump is being used to empty a flooded basement.

In one minute, 400 litres of water are pumped out of the basement.

The water is raised 8 metres and is ejected through a pipe at a speed of $2\,\mathrm{m\,s^{-1}}$.

The mass of 400 litres of water is 400 kg.

(a) Calculate the gain in potential energy of the 400 litres of water. *(1 mark)*

(b) Calculate the gain in kinetic energy of the 400 litres of water. *(1 mark)*

(c) Hence calculate the power of the pump, giving your answer in watts. *(2 marks)*

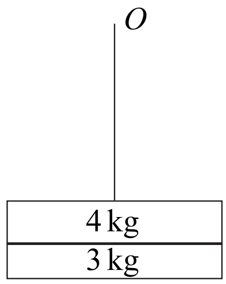
(Q3, Jan 2011)

24 (a) An elastic string has natural length l and modulus of elasticity λ. The string is stretched from length l to length $l + e$.

Show, by integration, that the work done in stretching the string is $\frac{\lambda e^2}{2l}$. *(3 marks)*

(b) A block, of mass 4 kg, is attached to one end of a light elastic string. The string has natural length 2 m and modulus of elasticity 196 N. The other end of the string is attached to a fixed point O.

(i) A second block, of mass 3 kg, is attached to the 4 kg block and the system hangs in equilibrium, as shown in the diagram.



Find the extension in the string. *(3 marks)*

(ii) The block of mass 3 kg becomes detached from the 4 kg block and falls to the ground. The 4 kg block now begins to move vertically upwards.

Find the extension of the string when the 4 kg block is next at rest. *(6 marks)*

(iii) Find the extension of the string when the speed of the 4 kg block is a maximum. *(3 marks)*

(Q7, Jan 2011)

25 In an Olympic diving competition, Kim, who has mass 58 kg, dives from a fixed platform, 10 metres above the surface of the pool. She leaves the platform with a speed of $2\,\text{m}\,\text{s}^{-1}$.

Assume that Kim's weight is the only force that acts on her after she leaves the platform. Kim is to be modelled as a particle which is initially 1 metre above the platform.

(a) Calculate Kim's initial kinetic energy. *(2 marks)*

(b) By using conservation of energy, find Kim's speed when she is 6 metres below the platform. *(5 marks)*

(Q1, June 2011)

26 A train consists of an engine and five carriages. A constant resistance force of 3000 N acts on the engine, and a constant resistance force of 400 N acts on each of the five carriages.

The maximum speed of the train on a horizontal track is $90\,\text{km}\,\text{h}^{-1}$.

(a) Show that this speed is $25\,\text{m}\,\text{s}^{-1}$. *(1 mark)*

(b) Hence find the maximum power output of the engine. Give your answer in kilowatts. *(3 marks)*

(Q5, June 2011)

27 At a theme park, a light elastic rope is used to bring a carriage to rest at the end of a ride.

The carriage has mass 200 kg and is travelling at $8\,\text{m}\,\text{s}^{-1}$ when the elastic rope is attached to the carriage as it passes over a point O. The other end of the elastic rope is fixed to the point O. The carriage then moves along a horizontal surface until it is brought to rest. The elastic rope is then detached so that the carriage remains at rest.

The elastic rope has natural length 6 m and modulus of elasticity 1800 N. The rope, once taut, remains horizontal throughout the motion.

(a) Calculate the elastic potential energy of the rope when the carriage is 10 m from O. *(3 marks)*

(b) A student's simple model assumes that there are no resistance forces acting on the carriage so that it is brought to rest by the elastic rope alone.

Find the distance of the carriage from O when it is brought to rest. *(3 marks)*

(c) The student improves the model by also including a constant resistance force of 800 N which acts while the carriage is in motion.

Find the distance of the carriage from O when it is brought to rest. *(8 marks)*

(Q9, June 2011)

28 A plane is dropping packets of aid as it flies over a flooded village. The speed of a packet when it leaves the plane is $60\,\text{m}\,\text{s}^{-1}$. The packet has mass 25 kg.

The packet falls a vertical distance of 34 metres to reach the ground.

(a) Calculate the kinetic energy of the packet when it leaves the plane. *(2 marks)*

(b) Calculate the potential energy lost by the packet as it falls to the ground. *(2 marks)*

(c) Assume that the effect of air resistance on the packet as it falls can be neglected.

(i) Find the kinetic energy of the packet when it reaches the ground. *(2 marks)*

(ii) Hence find the speed of the packet when it reaches the ground. *(2 marks)*

(Q1, Jan 2012)

29 A car travels along a straight horizontal road. When its speed is $v\,\text{m}\,\text{s}^{-1}$, the car experiences a resistance force of magnitude $25v$ newtons.

(a) The car has a maximum constant speed of $42\,\text{m}\,\text{s}^{-1}$ on this road.

Show that the power being used to propel the car at this speed is 44 100 watts. *(2 marks)*

(b) The car has mass 1500 kg.

Find the acceleration of the car when it is travelling at $15\,\text{m}\,\text{s}^{-1}$ on this road under a power of 44 100 watts. *(4 marks)*

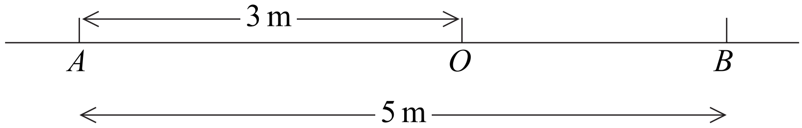
(Q4, Jan 2012)

30 An elastic string has one end attached to a point O fixed on a rough horizontal surface. The other end of the string is attached to a particle of mass 2 kg. The elastic string has natural length 0.8 metres and modulus of elasticity 32 newtons.

The particle is pulled so that it is at the point A, on the surface, 3 metres from the point O.

(a) Calculate the elastic potential energy when the particle is at the point A. *(3 marks)*

(b) The particle is released from rest at the point A and moves in a straight line towards O. The particle is next at rest at the point B. The distance AB is 5 metres.



Find the frictional force acting on the particle as it moves along the surface. *(6 marks)*

(c) Show that the particle does not remain at rest at the point B. *(2 marks)*

(d) The particle next comes to rest at a point C with the string slack.

Find the distance BC. *(2 marks)*

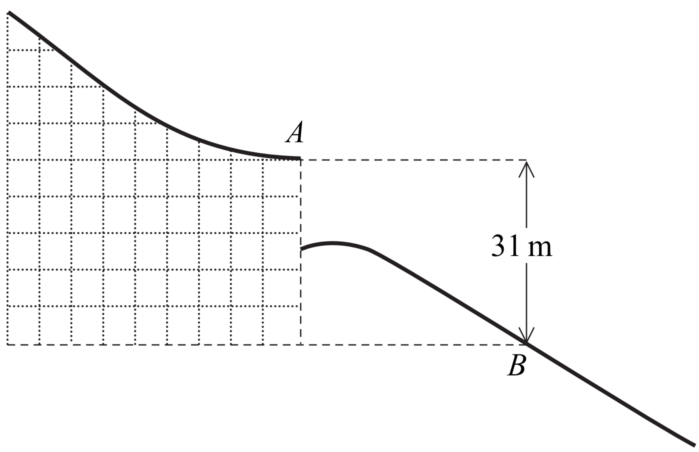
(e) Hence, or otherwise, find the total distance travelled by the particle after it is released from the point A. *(1 mark)*

(Q8, Jan 2012)

31 Alan, of mass 76 kg, performed a ski jump. He took off at the point A at the end of the ski run with a speed of $28\,\mathrm{m\,s^{-1}}$ and landed at the point B.

The level of the point B is 31 metres vertically below the level of the point A, as shown in the diagram.

Assume that his weight is the only force that acted on Alan during the jump.



(a) Calculate the kinetic energy of Alan when he was at the point A. *(2 marks)*

(b) Calculate the potential energy lost by Alan during the jump as he moved from the point A to the point B. *(2 marks)*

(c) (i) Find the kinetic energy of Alan when he reached the point B. *(2 marks)*

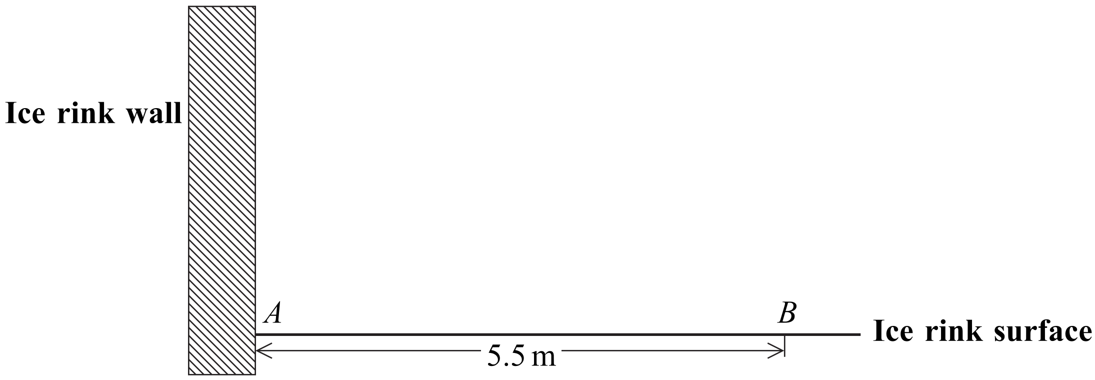
(ii) Hence find the speed of Alan when he reached the point B. *(2 marks)*

(Q1, June 2012)

32 Zoë carries out an experiment with a block, which she places on the horizontal surface of an ice rink. She attaches one end of a light elastic string to a fixed point, A, on a vertical wall at the edge of the ice rink at the height of the surface of the ice rink.

The block, of mass 0.4 kg, is attached to the other end of the string. The string has natural length 5 m and modulus of elasticity 120 N.

The block is modelled as a particle which is placed on the surface of the ice rink at a point B, where AB is perpendicular to the wall and of length 5.5 m.



The block is set into motion at the point B with speed $9\,\text{m s}^{-1}$ directly towards the point A. The string remains horizontal throughout the motion.

(a) Initially, Zoë assumes that the surface of the ice rink is smooth.

Using this assumption, find the speed of the block when it reaches the point A.

(4 marks)

(b) Zoë now assumes that friction acts on the block. The coefficient of friction between the block and the surface of the ice rink is μ.

(i) Find, in terms of g and μ, the speed of the block when it reaches the point A.

(6 marks)

(ii) The block rebounds from the wall in the direction of the point B. The speed of the block immediately after the rebound is half of the speed with which it hit the wall.

Find μ if the block comes to rest just as it reaches the point B. *(6 marks)*

(Q8, June 2012)

33 Tim is playing cricket. He hits a ball at a point A. The speed of the ball immediately after being hit is $11\,\mathrm{m\,s^{-1}}$.

The ball strikes a tree at a point B. The height of B is 5 metres above the height of A.

The ball is to be modelled as a particle of mass 0.16 kg being acted upon only by gravity.

(a) Calculate the initial kinetic energy of the ball. *(2 marks)*

(b) Calculate the potential energy gained by the ball as it moves from the point A to the point B. *(2 marks)*

(c) (i) Find the kinetic energy of the ball immediately before it strikes the tree. *(2 marks)*

(ii) Hence find the speed of the ball immediately before it strikes the tree. *(2 marks)*

(Q1, Jan 2013)

34 A van, of mass 1500 kg, travels at a constant speed of $22\,\mathrm{m\,s^{-1}}$ up a slope inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{25}$.

The van experiences a resistance force of 8 000 N.

Find the power output of the van's engine, giving your answer in kilowatts.

(5 marks)

(Q3, Jan 2013)

35 (a) An elastic string has natural length l and modulus of elasticity λ. The string is stretched from length l to length $l + e$.

Show, by integration, that the work done in stretching the string is $\dfrac{\lambda e^2}{2l}$. *(3 marks)*

(b) A particle, of mass 5 kg, is attached to one end of a light elastic string. The other end of the string is attached to a fixed point O.

The string has natural length 1.6 m and modulus of elasticity 392 N.

(i) Find the extension of the string when the particle hangs in equilibrium. *(2 marks)*

(ii) The particle is pulled down to a point A, which is 2.2 m below the point O.

Calculate the elastic potential energy in the string. *(3 marks)*

(iii) The particle is released when it is at rest at the point A.

Calculate the distance of the particle from the point A when its speed first reaches $0.8\,\mathrm{m\,s^{-1}}$. *(5 marks)*

(Q8, Jan 2013)

36 Carol, a circus performer, is on a swing. She jumps off the swing and lands in a safety net. When Carol leaves the swing, she has a speed of $7\,\mathrm{m\,s^{-1}}$ and she is at a height of 8 metres above the safety net.

Carol is to be modelled as a particle of mass 52 kg being acted upon only by gravity.

(a) Find the kinetic energy of Carol when she leaves the swing. *(2 marks)*

(b) Show that the kinetic energy of Carol when she hits the net is 5350 J, correct to three significant figures. *(3 marks)*

(c) Find the speed of Carol when she hits the net. *(3 marks)*

(Q2, June 2013)

37 A train, of mass 22 tonnes, moves along a straight horizontal track. A constant resistance force of 5000 N acts on the train. The power output of the engine of the train is 240 kW.

Find the acceleration of the train when its speed is $20\,\mathrm{m\,s^{-1}}$. *(6 marks)*

(Q7, June 2013)

38 Two particles, A and B, are connected by a light elastic string that passes through a hole at a point O in a rough horizontal table. The edges of the hole are smooth. Particle A has a mass of 8 kg and particle B has a mass of 3 kg.

The elastic string has natural length 3 metres and modulus of elasticity 60 newtons.

Initially, particle A is held 3.5 metres from the point O on the surface of the table and particle B is held at a point 2 metres vertically below O.

The coefficient of friction between the table and particle A is 0.4 .

The two particles are released from rest.

(a) (i) Show that initially particle A moves towards the hole in the table. *(3 marks)*

(ii) Show that initially particle B also moves towards the hole in the table. *(2 marks)*

(b) Calculate the **initial** elastic potential energy in the string. *(2 marks)*

(c) Particle A comes permanently to rest when it has moved 0.46 metres, at which time particle B is still moving upwards.

Calculate the distance that particle B has moved when it is at rest for the first time. *(7 marks)*

(Q9, June 2013)