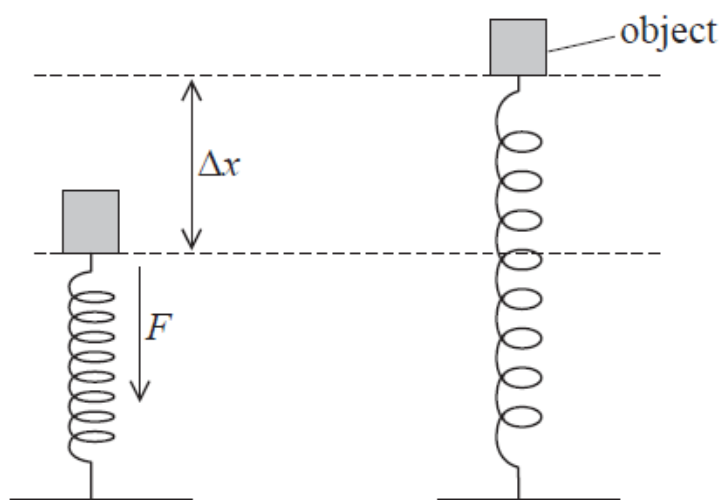


Questions

Q1.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☐ and then mark your new answer with a cross ☐.

An object of mass m is resting on top of a spring. The spring is compressed a further distance Δx by a vertical force F . The force is removed and the spring returns to its original length as shown.



When Δx becomes zero the object has a vertical speed v .

Which of the following equations describes the energy transfer as the spring returns to its original length?

- ☐ A $\frac{1}{2} F \Delta x = \frac{1}{2} m v^2 - m g \Delta x$
- ☐ B $\frac{1}{2} F \Delta x = \frac{1}{2} m v^2 + m g \Delta x$
- ☐ C $F \Delta x = \frac{1}{2} m v^2 - m g \Delta x$
- ☐ D $F \Delta x = \frac{1}{2} m v^2 + m g \Delta x$

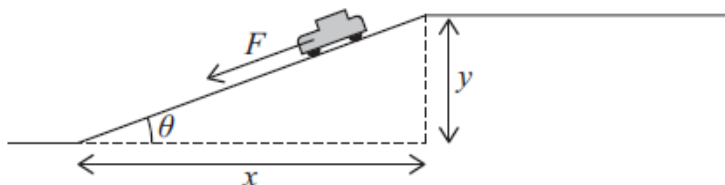
(Total for question = 1 mark)

Q2.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

A toy car rolled down a ramp. The ramp was at an angle θ to the horizontal.

The resultant force on the car was F . The car moved a horizontal distance x and a vertical distance y , as shown.



Which of the following expressions gives the work done by F as the car moved down the ramp?

- ☐ A Fx
- ☐ B $\frac{Fx}{\cos \theta}$
- ☐ C Fy
- ☐ D $Fy \sin \theta$

(Total for question = 1 mark)

Q3.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

An electric pump has an output power of 25 kW and an efficiency of 52%.

Which of the following expressions gives the rate in kW at which energy is dissipated?

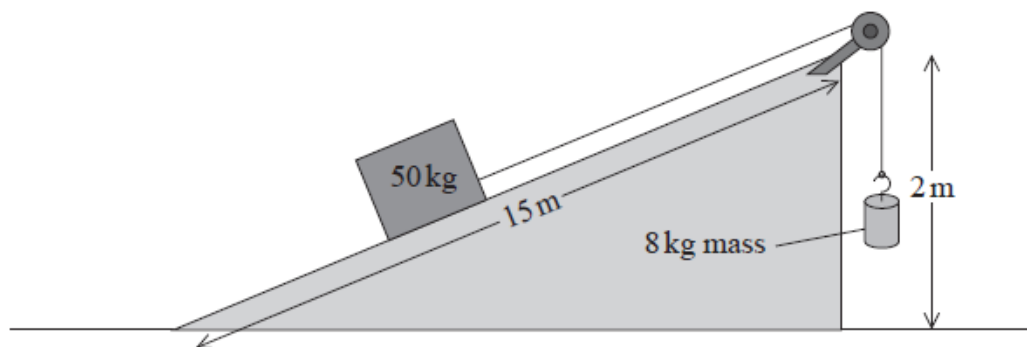
- ☐ A 0.48×25
- ☐ B 0.52×25
- ☐ C $\frac{0.48 \times 25}{0.52}$
- ☐ D $\frac{25}{0.52}$

(Total for question = 1 mark)

Q4.

Machines make work easier by changing the size or direction of a force. A student designed a simple machine to lift a box of mass 50 kg. The student claimed the efficiency of the machine was greater than 90%.

The machine used a slope of height 2.0 m and length 15 m to move the box. The box was connected to an 8.0 kg mass by a rope over a pulley as shown. As the 8.0 kg mass fell, the box moved up the slope at a steady speed.



Determine whether the maximum efficiency of the machine was greater than 90%.

(4)

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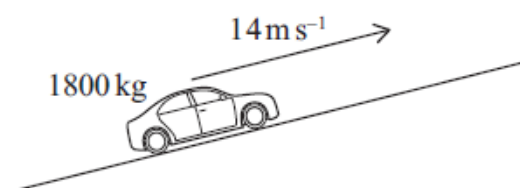
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(Total for question = 4 marks)

Q5.

The brakes in a car reduce the kinetic energy of the car. In an electric car, some of this energy is transferred to the battery in the car.

An electric car of mass 1800 kg moves at a speed of 14 m s^{-1} up a hill, as shown.



The driver applies the brakes to bring the car to a stop. During braking, the vertical displacement of the car is 0.76 m and the energy stored in the battery increases by 45 kJ.

Calculate the efficiency of using the brakes to charge the battery.

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Efficiency = ...

(Total for question = 4 marks)

Q6.

A toy car is released from rest and rolls down a slope, as shown.



mass of car = 0.160 kg

speed of car at bottom of slope = 2.6 m s^{-1}

(a) Calculate the increase in kinetic energy of the car as it accelerates down the slope.

(2)

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Increase in kinetic energy = ...

(b) As the car accelerates down the slope, the work done against frictional forces is 0.26 J.

Calculate the vertical displacement of the car.

(2)

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Vertical displacement of car = ...

(Total for question = 4 marks)

Q7.

A train moves up an inclined track at constant velocity. The train moves through a vertical height of 25 m.

(a) Show that the gravitational potential energy gained by the train is about 400 MJ.

mass of train = 1.7×10^6 kg

(2)

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(b) The train's engine has an output power of 20 MW. The train takes a time of 35 s to move through the vertical height of 25 m.

Calculate the work done by the engine against resistive forces.

(3)

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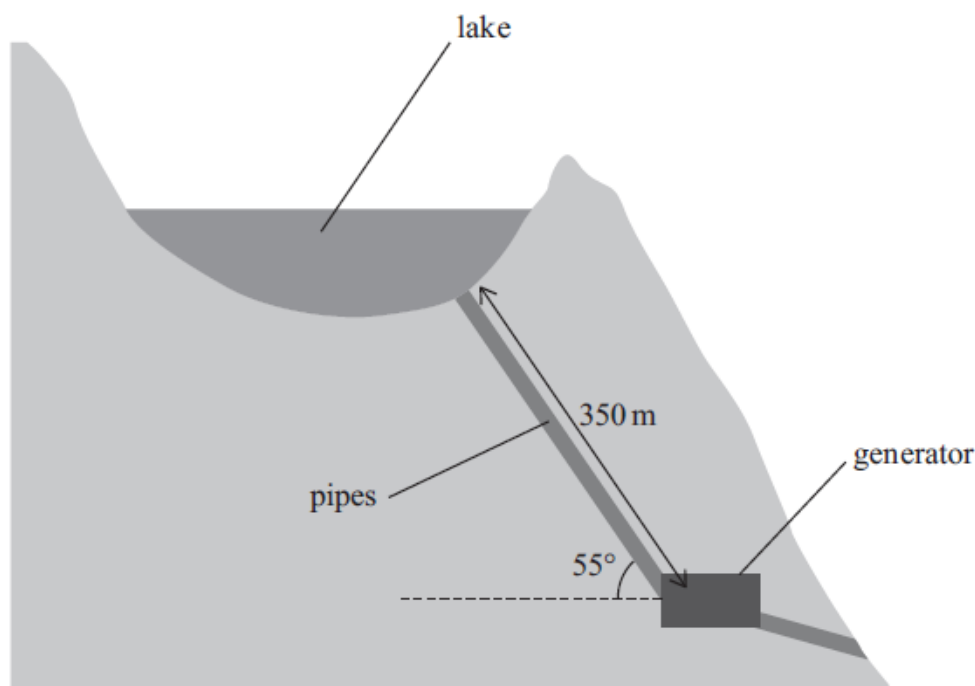
Work done = ...

(Total for question = 5 marks)

Q8.

The Cruachan hydroelectric power station in Scotland is built inside a mountain.

Water from a lake near the top of the mountain flows through straight pipes to a generator. The pipes have a length of 350 m and are inclined at an angle of 55° to the horizontal, as shown.



The gravitational potential energy of the water in the lake is used to generate electrical power.

(a) In one minute, each pipe transfers 1700 m^3 of water to the generator. The density of the water in the lake is 1100 kg m^{-3} .

Show that the power transferred by the water in each pipe is about 88 MW.

(5)

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(b) Water travels from the lake to the generator through 4 identical pipes.

As water moves through the 4 pipes to the generator, the total power wasted is 256 MW.

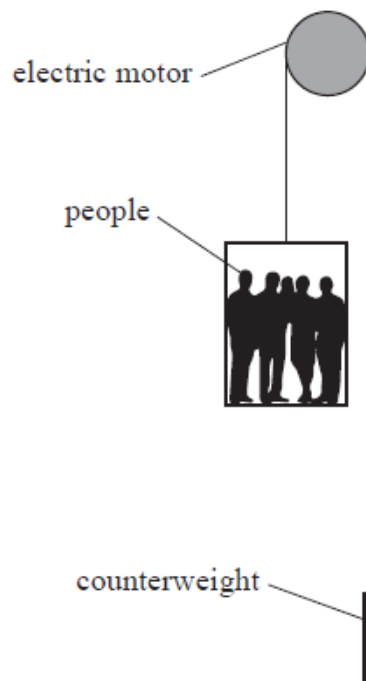
Calculate the efficiency of the power station.

Efficiency = ...

(Total for question = 7 marks)

Q9.

The diagram shows a lift system for moving people up and down a tall building. There is a counterweight to balance the weight of the lift. An electric motor is used to raise and lower the lift.



(a) Explain how the counterweight affects the amount of work required from the electric motor to raise the lift.

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(b) The electric motor raises the lift through a height of 40.0 m in a time of 30.0 s.

Show that the output power of the electric motor is about 12 kW.

total mass of lift and people = 2 250 kg
mass of counterweight = 1 300 kg

(4)

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(c) The electric motor dissipates energy to the surroundings at a rate of 3 600 W.

Determine the efficiency of the electric motor.

(2)

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Efficiency = ...

(Total for question = 8 marks)

Q10.

A regenerative braking system allows an electric car to use its kinetic energy to charge a battery as the car decelerates.

(a) A car travelling at 13.0 m s^{-1} decelerated to rest.

The energy transferred to the car's battery during the deceleration was 73.9 kJ.

Calculate the efficiency of the regenerative braking system.

mass of car = 1560 kg

(3)

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Efficiency = ...

(b) (i) Drag forces act on the car as it moves through the air.

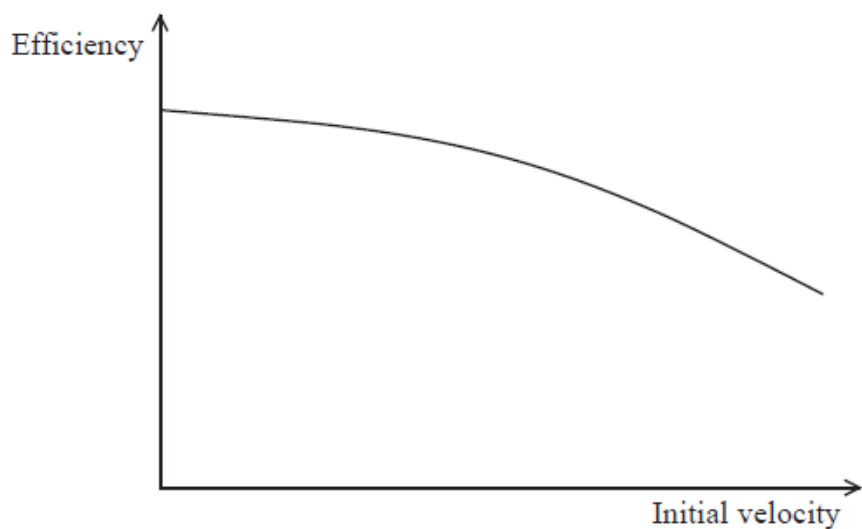
State how the drag forces vary with the velocity of the car.

(1)

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(ii) The graph shows how the efficiency of the regenerative braking system depends upon the initial velocity of the car for initial velocities in the range 20 m s^{-1} to 40 m s^{-1} .



Explain why the efficiency of the regenerative braking system varies as shown in the graph.

(4)

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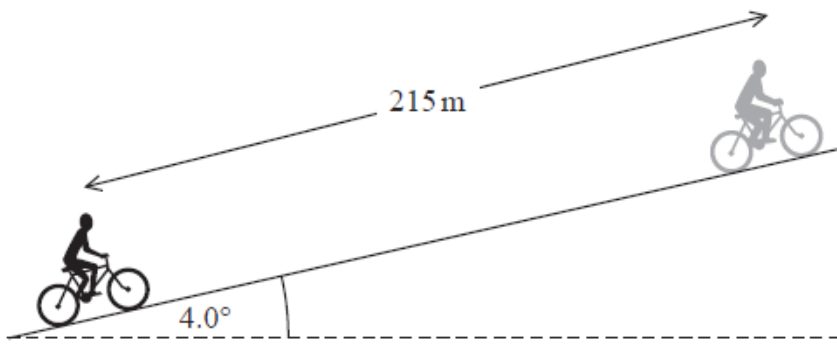
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(Total for question = 8 marks)

Q11.

A cyclist is moving up a slope at a constant speed. The angle of the slope to the horizontal is 4.0° , as shown.



As the cyclist pedals, there is a constant forward force on the bicycle of 150 N. The cyclist travels 215 m along the slope.

(a) Show that the work done by the cyclist is about 3×10^4 J.

(2)

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(b) The cyclist must do work against the force of gravity and air resistance.

(i) Calculate the work done by the cyclist against air resistance.

mass of cyclist and bicycle = 90 kg

(4)

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Work done against air resistance = ...

(ii) State one assumption that must be made when calculating the work done against air resistance.

(1)

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(c) At the top of the slope, the road becomes horizontal. The cyclist continues to pedal with the same force.

Explain how the speed of the cyclist changes as the road becomes horizontal.

(2)

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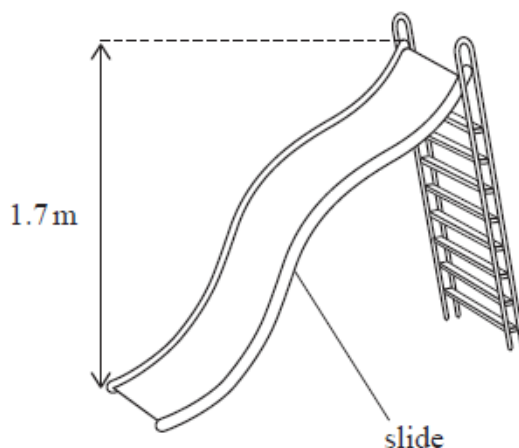
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(Total for question = 9 marks)

Q12.

A child's slide has a vertical height of 1.7 m as shown.



(a) A child starts from rest at the top of the slide and moves down the slide.

The resistive forces acting on the child can be ignored.

(i) Explain why the equations of motion should **not** be used to determine the maximum speed of the child.

You should consider the shape of the slide.

(3)

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(ii) The child has a mass of 24 kg.

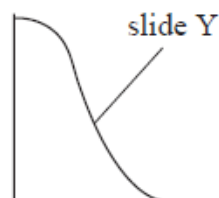
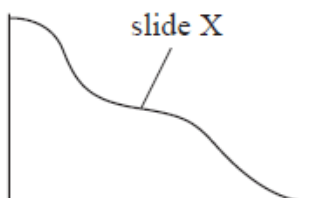
Determine the maximum speed v of the child on the slide.

(3)

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 $v =$

(b) Two slides, X and Y, have the same height.

Slide X is longer than slide Y, as shown.



A child moves from rest down slide X and reaches a maximum speed v_X .

A second child moves from rest down slide Y and reaches a maximum speed v_Y .

The child on slide Y has a greater mass than the child on slide X.

The resistive forces acting on both children can be ignored.

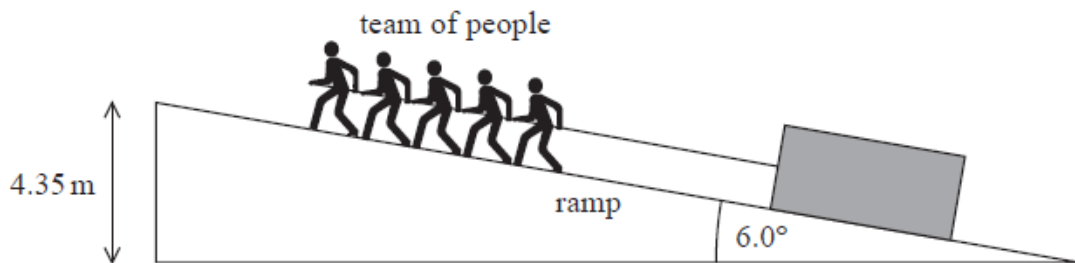
Explain how v_X compares with v_Y .

(3)

(Total for question = 9 marks)

Q13.

The diagram shows a system used to move a stone block up a ramp. A team of people uses a rope to pull the block at a constant speed.



height of ramp = 4.35 m
angle of ramp to horizontal = 6.0°
mass of block = $2.10 \times 10^3 \text{ kg}$
speed of block up ramp = 0.450 m s^{-1}
total power of team = 6.25 kW

(a) Show that the total force that the team exerts on the block is about 14 kN.

(2)

(b) Determine the total work done by the team.

(3)

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Total work done = ...

(c) Show that the useful work done on the block is about 90 kJ.

(2)

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(d) Determine the efficiency of the system.

(2)

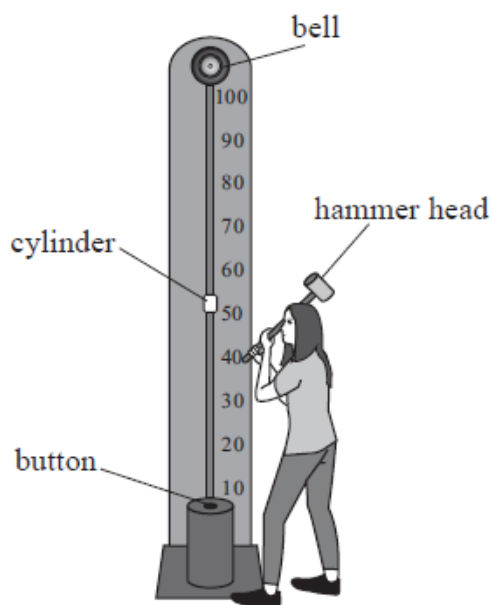
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Efficiency = ...

(Total for question = 9 marks)

Q14.

In a game called 'High Striker' a person hits a button with a hammer. This causes a cylinder to move towards the bell at the top, as shown.



(a) The kinetic energy of the hammer head as it hits the button is greater than the change in gravitational potential energy of the hammer head as it moves down.

Explain why.

(3)

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(b) The hammer is initially at rest at its highest point. As the person moves the hammer head towards the button, the average resultant force on the hammer head is 58 N.

The hammer head moves a distance of 1.2 m before hitting the button. The cylinder must move 2.7 m upwards to hit the bell.

Deduce whether the cylinder hits the bell.

mass of cylinder = 0.15 kg
 efficiency of energy transfer = 4.0 %

(5)

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(c) If the velocity of the hammer head as it hits the button doubles, the height gained by the cylinder does **not** double.

Explain why.

(2)

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(Total for question = 10 marks)