Name: _____

Power

Questions

Date:

Time:

Total marks available: 56

Total marks achieved: _____

Questions

Q1. An electric motor with potential difference V and current I lifts a mass m through a height h in time t at a steady speed v.

The efficiency of the motor is given by

☒ **A** $\frac{\frac{1}{2}mv^2}{VIt}$

☒ **B** $\frac{VI}{mg}$

☒ **C** $\frac{VIt}{mv}$

☒ **D** $\frac{mgh}{VIt}$

(Total for Question = 1 mark)

Q2.

A mass of 0.05 kg is lifted at a slow steady speed by a 5 W electric motor.

The height the mass rises in 8 s is found using

☒ **A** $\frac{5}{0.05 \times 9.81 \times 8}$

☒ **B** $\frac{5 \times 8}{0.05 \times 9.81}$

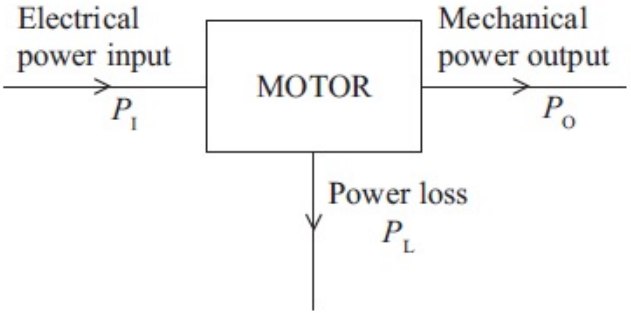
☒ **C** $\frac{0.05 \times 9.81}{5 \times 8}$

☒ **D** $\frac{0.05 \times 9.81 \times 8}{5}$

(Total for question = 1 mark)

Q3.

Electrical power is transferred in a motor as shown.



What is the efficiency of the motor?

$\frac{P_L}{P_I}$ **A** $\frac{P_O + P_L}{P_I}$

$\frac{P_L}{P_I}$ **B** $\frac{P_I}{P_O}$

$\frac{P_L}{P_I}$ **C** $\frac{P_L}{P_I}$

$\frac{P_L}{P_I}$ **D** $\frac{P_O}{P_I}$

(Total for question = 1 marks)

Q4.

A student investigates how the efficiency of an electric motor being used to raise a load varies with the weight of the load.

The time taken for the motor to lift a load from the floor to the maximum height was measured using a stopwatch. The load was varied by adding weights, each marked '1.00 N'.

The spreadsheet shows the student's results (columns A to E) and calculation (column F).

	A	B	C	D	E	F
1	load /N	current / A	potential difference / V	time / s	change in height / m	efficiency
2	2.00	1.8	4.6	1.52	0.825	0.13
3	3.00	1.9	4.4	2.05	0.825	0.14
4	4.00	2.1	4.3	2.19	0.825	0.17
5	5.00	2.3	5.1	2.26	0.825	0.16
6	6.00	2.5	4.5	2.48	0.825	0.18
7	7.00	3.1	5.2	2.17	0.825	0.17
8	8.00	3.7	4.8	2.68	0.825	0.14
9	9.00	3.9	4.8	3.36	0.825	0.12
10	10.00	4.2	4.7	3.72	0.825	0.11

Explain how the value in cell F4 has been determined using the results obtained.

(3)

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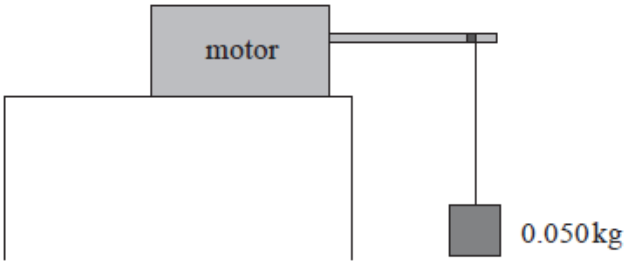
(Total for question = 3 marks)

Q5.

A motor lifts a block of mass 0.050kg at a constant velocity of 0.40 m s^{-1}.

The current in the motor is 85mA and the potential difference across it is 3.0V.



Calculate the efficiency of the motor.

(3)

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Efficiency of the motor = ...

(Total for question = 3 marks)

Q6.

When food is cooked in a microwave oven, microwave radiation is absorbed by water molecules, increasing the internal energy of the food.

A student heats water in a microwave oven for 1 minute to determine the efficiency of the oven at transferring energy to the water. The current in the microwave oven is 5.0 A and the potential difference is 230 V. The increase in internal energy of the water is 29 000 J.

Calculate the efficiency of the microwave oven at heating the water.

(4)

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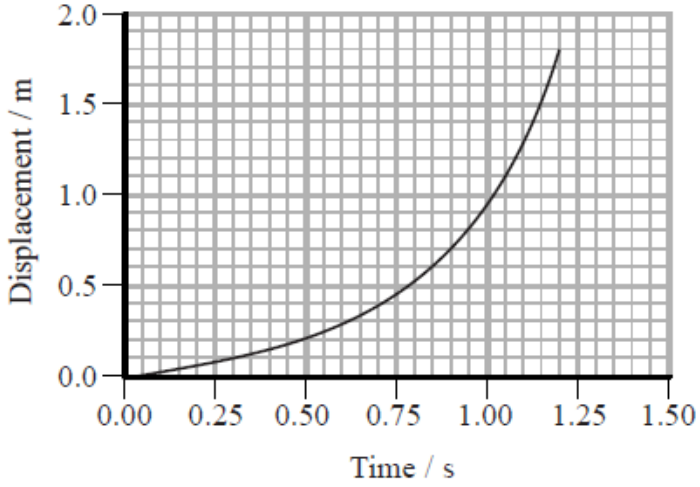
Efficiency = ...

Q7.

A small, gas-filled balloon was dropped from a height. The displacement-time graph for the balloon is shown.



As the displacement of the balloon from its point of release increased, gravitational potential energy was transferred to kinetic energy and thermal energy.

(a) State why the rate of energy transfer was greatest at 1.20 s.

(1)

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(b) By calculating the change in gravitational potential energy of the balloon between 1.05 s and 1.20 s, show that the average rate at which the gravitational potential energy was transferred during this time interval was about 0.2 W.

mass of balloon and air = 0.004 kg

(3)

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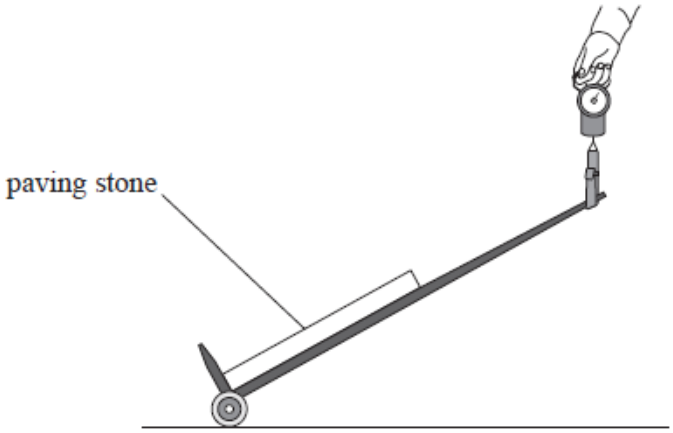
(Total for question = 4 marks)

Q8.

A gardener used a trolley to move a paving stone.



A force meter was attached to the handle of the trolley.

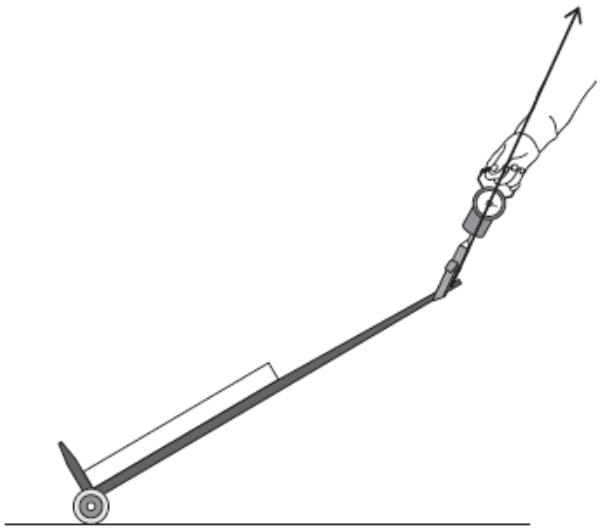
The gardener recorded the following measurements when the trolley was at rest in the position shown in the diagram.

mass of trolley and paving stone = 18.5 kg

length of trolley = 97 cm

force on handle = 50 N

The gardener then pulled the trolley and measured the applied force while the trolley was moving.



The direction of the applied force is 25° to the vertical, as shown by the arrow.

(i) Calculate the magnitude of the applied force.

Assume the magnitude of the vertical component of the force remains at 50 N.

(2)

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Magnitude of applied force = ...

(ii) The gardener continues to walk and pulls the trolley a distance of 15 m in a time of 4.2 s.

Calculate the power developed while pulling the trolley.

(3)

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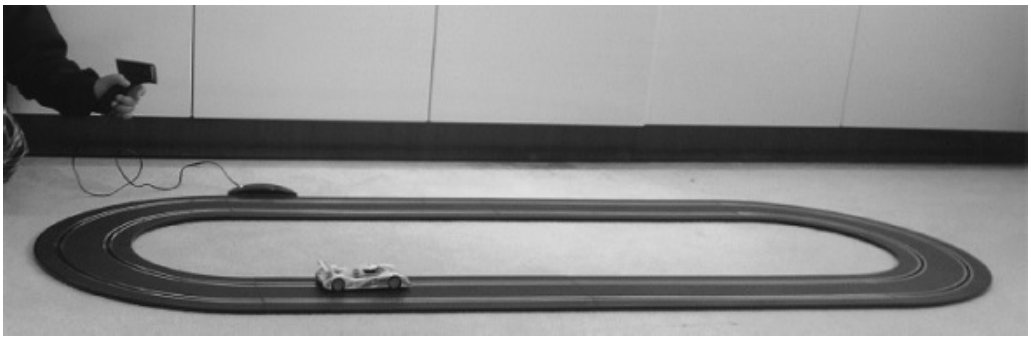
Power = ...

(Total for question = 5 marks)

Q9. The picture shows a track for racing toy electric cars. A guide pin fits in a groove in the track to keep the car on the track. A small electric motor in the car is controlled, with a hand-controller, via contacts in the track.



A child places a car of mass 95 g on the track. She adjusts the controller to a power of 4.2 W so the car accelerates from rest for 0.40 s.

(a) (i) Show that the energy transferred by the motor in 0.40 s is about 2 J.

(2)

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(ii) Calculate the speed of the car at 0.40 s.

(2)

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Speed = ...

(iii) Suggest why the actual speed of the car is less than the calculated speed.

(1)

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(b) At high speed the guide pin may become disengaged from the groove.

Use Newton's first law to explain why the car would then leave the track at a corner.

(2)

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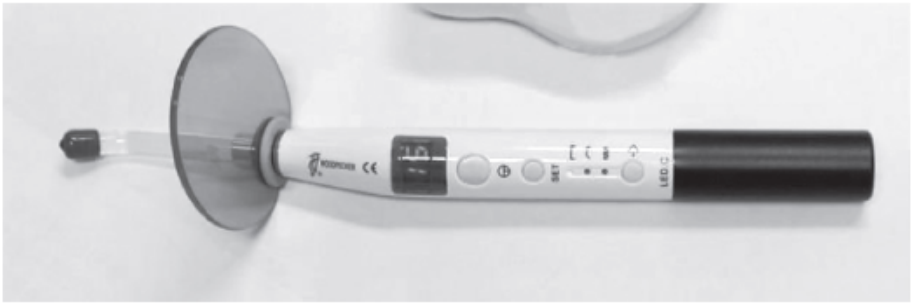
(Total for Question = 7 marks)

Q10.

Dentists often use a white composite material for fillings for teeth. This material is applied as a

liquid and then hardened using blue light.

The photograph shows a light gun, used by dentists, that emits the blue light.



© Zhengzhou Smile Dental Equipment Co., Ltd.

(a) The light gun emits light of radiation flux 8000 W m^{-2}.

A particular tooth needs a filling of cross-sectional area 1.5×10^{-5} m^2. It requires 2.3 J of incident light energy to harden the filling.

Calculate the time for which the light must be applied.

(3)

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Time = ...

(b) The light gun is supplied with a rechargeable battery of capacity 1.4 amp hours. When in use, the output potential difference of the battery is 3.7 V.

(i) Assuming the potential difference is constant, show that the maximum energy supplied by the battery is about 20 000 J.

(2)

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(ii) Assuming each filling requires 2.3 J of incident light energy, a fully charged battery can be used to power the light gun to harden 210 fillings.

Calculate the efficiency of the light gun at supplying the energy stored in the battery to the fillings.

(3)

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Efficiency = ...

(Total for question = 8 marks)

Q11.

An electric kettle is used to heat water from room temperature to boiling point.

(a) (i) Calculate the electrical power used by the kettle.

potential difference = 230 V

current = 12.5 A

(2)

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Electrical power = ...

(ii) The kettle is switched on for 140 s.

Calculate the total energy supplied to the kettle.

(2)

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Total energy supplied = ...

(iii) The amount of thermal energy transferred to the water is calculated to be 351 000 J.

Calculate the efficiency of the kettle at heating the water.

(3)

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Efficiency = ...

(b) A student suggests that the useful energy required is thermal and the kettle only produces thermal energy, so it should be 100 % efficient.

Discuss this suggestion.

(2)

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(Total for question = 8 marks)

Q12. The 'Stealth' roller coaster at the Thorpe Park theme park is advertised as reaching 135 km hour^{-1} from rest in 2.3 seconds.

Most roller coasters are driven slowly up to the top of a slope at the start of the ride. However the carriages on 'Stealth' are initially accelerated horizontally from rest at ground level by a hydraulic launch system, before rising to the top of the first slope.

(a) (i) Calculate the average acceleration of the carriages.

135 km hour^{-1} = 37.5 m s^{-1}

(2)

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Average acceleration = ...

(ii) Calculate the minimum average power which must be developed by the launch system.

mass of carriages and passengers = 10 000 kg

(3)

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Minimum average power = ...

(iii) Suggest why the power in (ii) is a minimum value.

(1)

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*(b) The force required to launch 'Stealth' is not always the same. The ride is monitored and the data from preceding launches is used to calculate the required force.

If the mass of the passengers for a particular ride is significantly more than for preceding launches, this can lead to 'rollback'. This is when the carriages do not quite reach the top of the first slope and return backwards to the start.

Explain why 'rollback' would occur in this situation.

(3)

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(c) Suggest why roller coasters may have a greater acceleration when the lubricating oil between the moving parts has had time to warm up.

(2)

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(Total for Question = 11 marks)