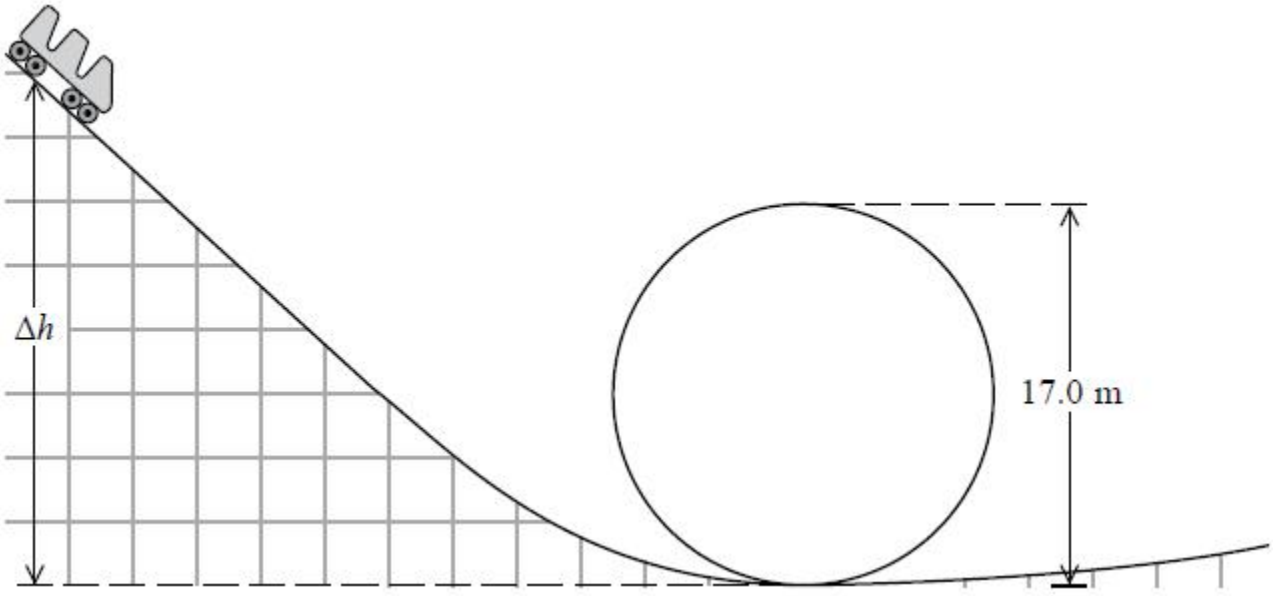
Name of the Student:_____
Max. Marks : 19 Marks **Time : 19 Minutes**

Q1.

The diagram shows the carriage of a rollercoaster about to enter a vertical loop of diameter 17.0 m. The carriage is initially at rest at a height Δ*h* above the bottom of the loop.



(i) So that a passenger remains in contact with their seat at the top of the ride, show that the minimum speed of the car at the top of the loop is 9.1 m s^{-1}.

(3)

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(ii) Calculate the minimum value of Δ*h* that will enable the passenger to remain in contact with their seat at the top of the loop.

(3)

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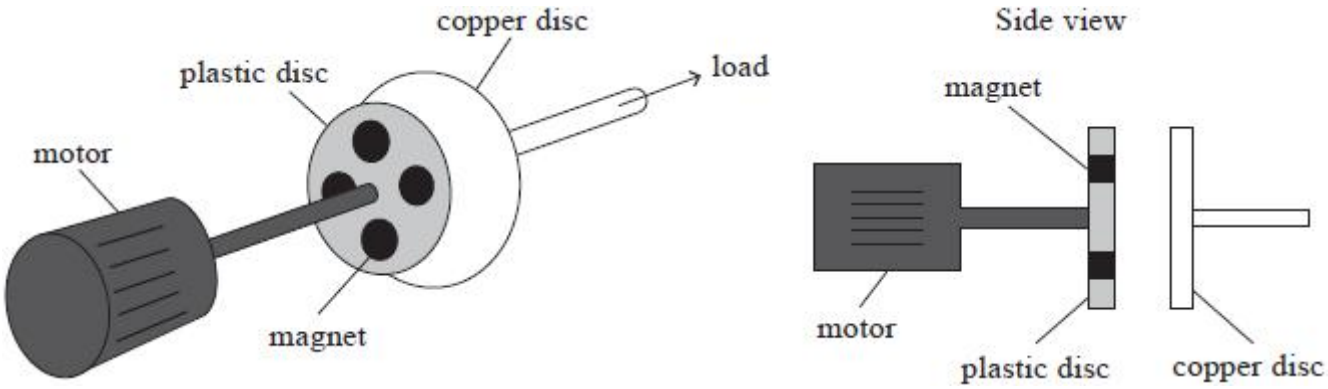
Δh = ...

(Total for question = 4 marks)

Q2.

A device called a clutch can be used to connect a motor to a load. The diagram shows a design called an eddy current clutch.



Several magnets are embedded in the plastic disc and it is rotated by the motor.

The motor rotates at 500 revolutions per minute.

Calculate the angular speed ω of the motor.

(2)

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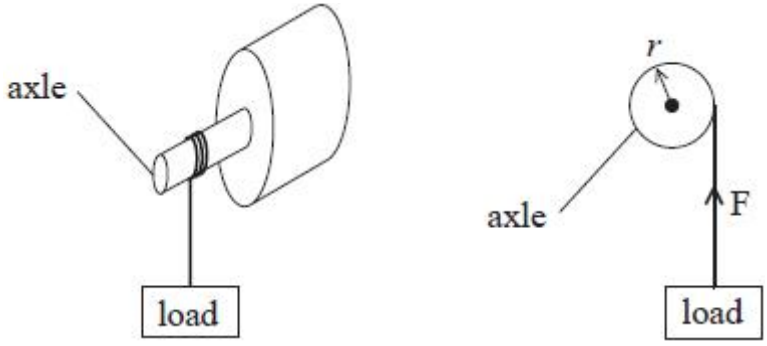
ω = ...

(Total for question = 2 marks)

Q3.

Motors usually have a rotating component which can do work W.

(a) A motor lifts a load in a time t. The axle of the motor has a radius r and exerts a force F.



The power produced by a motor can be calculated by using the following word equation.

Power = moment of the force exerted by the rotating axle × angular velocity

Derive this equation, starting with power $P = \frac{W}{t}$.

(4)

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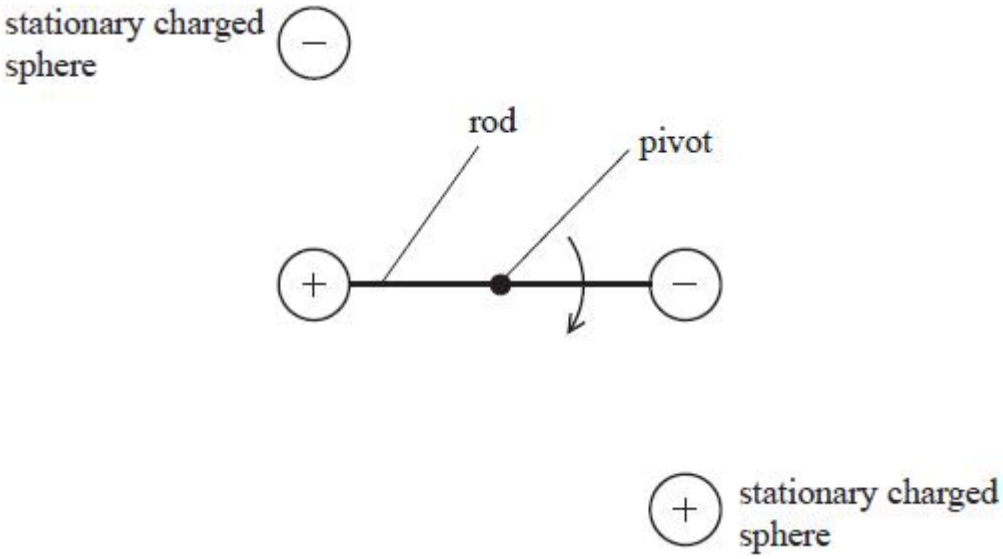
(b) An electrostatic motor was first demonstrated by Benjamin Franklin in 1750.

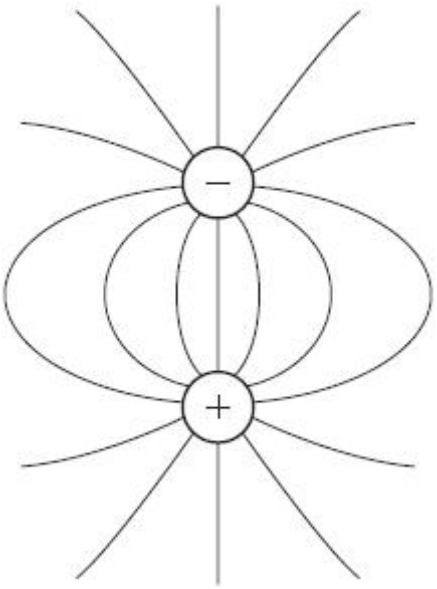
The diagram shows a simplified version of part of this motor.
This consists of a rod, with an oppositely charged sphere at either end, which rotates around a fixed pivot.
Two stationary charged spheres apply a force on the spheres at either end of the rod.



(i) In the diagram below, electric field lines have been drawn around one pair of these spheres.
Add to the diagram to show

- the directions of the field lines
- the lines of equipotential.

(3)



(ii) The distance between the centres of each charged sphere in this pair is 5.0 cm.
Show that the force between this pair of charged spheres is about 0.04 N.
charge on each sphere = 0.10 μC

(2)

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(c) The table shows the typical power and the corresponding angular velocity required for three different appliances.

	Power / W	Angular velocity / rad s^{-1}
Electric car	2.0×10^4	300
Vacuum cleaner	1.4×10^3	1000
Small pond pump	0.5	200

Deduce which of these appliances, in principle, could use the electrostatic motor in (b).
You should use the word equation in (a) and assume that the length of the rod in the electrostatic motor is 8.0 cm.
Assume that the electrostatic motor would deliver a constant force throughout one complete rotation.

(4)

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(Total for question = 13 marks)