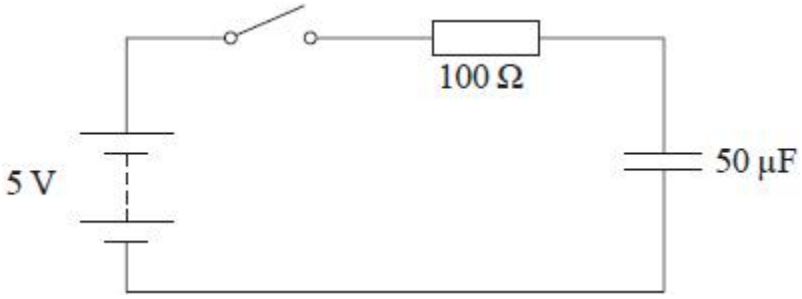
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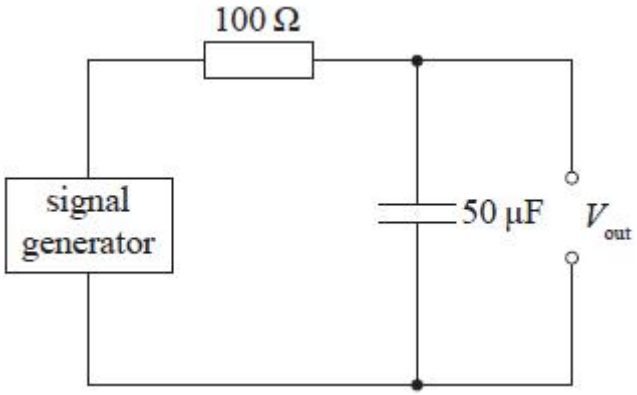
Max. Marks :18 Marks **Time : 18 Minutes**

Q1.

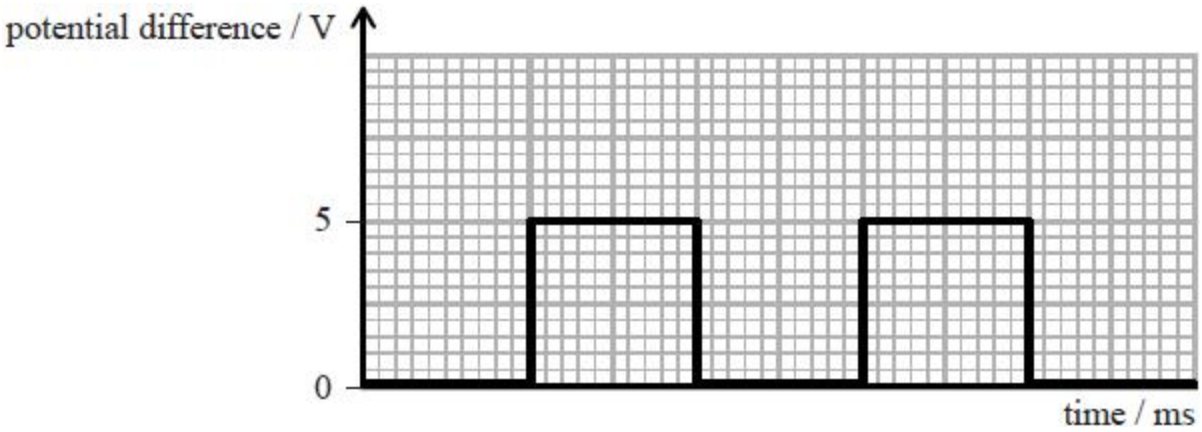
A circuit consists of a battery of e.m.f. 5 V and negligible internal resistance, a switch, a 100 Ω resistor and an uncharged 50 μF capacitor.



The battery and switch are replaced by a signal generator providing a square wave output of peak potential difference 5 V. The signal generator has negligible internal resistance.



The graph shows the square wave output of the signal generator. The frequency of the square wave is 20 Hz.



On the graph add values to the time axis and sketch a graph of the potential difference, V_{out}, across the capacitor for two cycles of the square wave. Assume the capacitor is initially uncharged.

(5)

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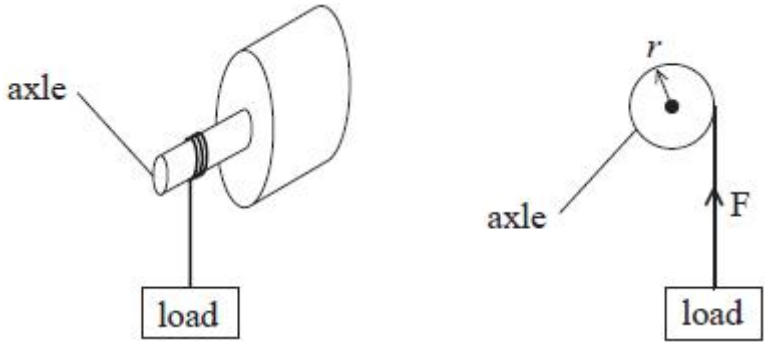
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(Total for question = 5 marks)

Q2.

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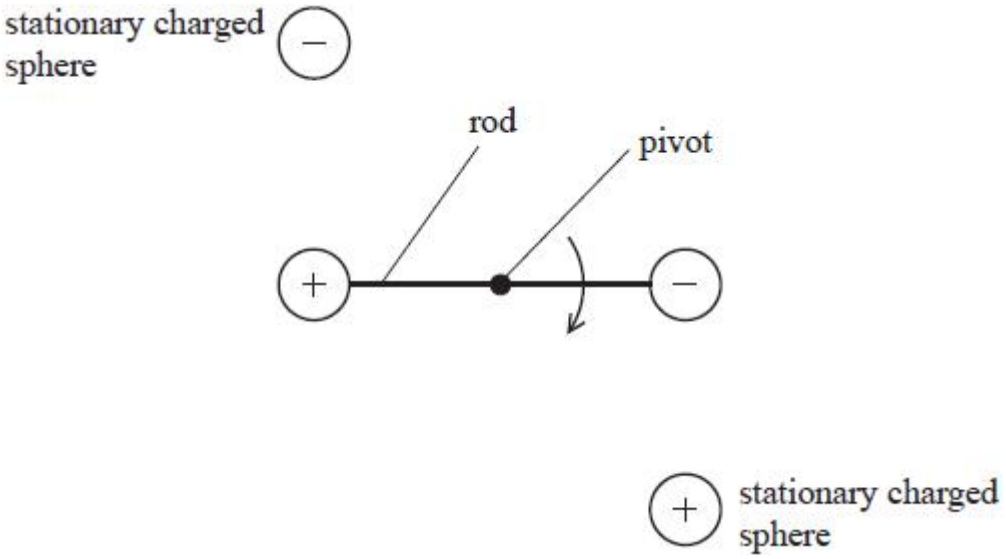
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(b) An electrostatic motor was first demonstrated by Benjamin Franklin in 1750.

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.

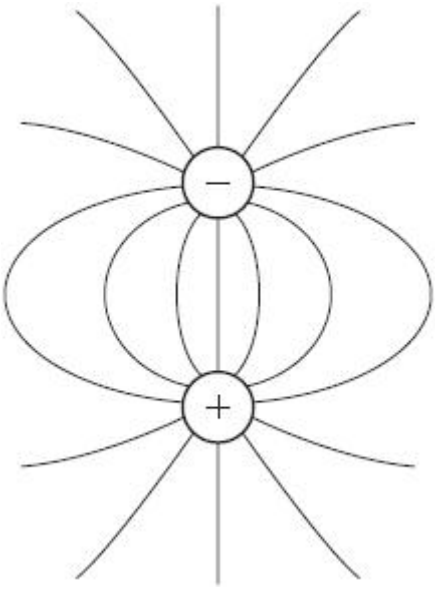
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(i) In the diagram below, electric field lines have been drawn around one pair of these spheres. Add to the diagram to show

- 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.

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	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)

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