Practice Question Set For A-Level
Subject : Physics
Paper-1 Topic: Further Mechanics

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Name of the Student:_____
Max. Marks : 26 Marks **Time : 26 Minutes**

Q1.

A roundabout in a fairground requires an input power of 2.5 kW when operating at a constant angular velocity of 0.47 rad s^{-1}.

(a) Show that the frictional torque in the system is about 5 kN m.

(3)

(b) When the power is switched off, the roundabout decelerates uniformly because the frictional torque remains constant. The roundabout takes a time of 34 s to come to rest.

(i) Calculate the moment of inertia of the roundabout.
Give an appropriate unit for your answer.

moment of inertia _____ unit _____

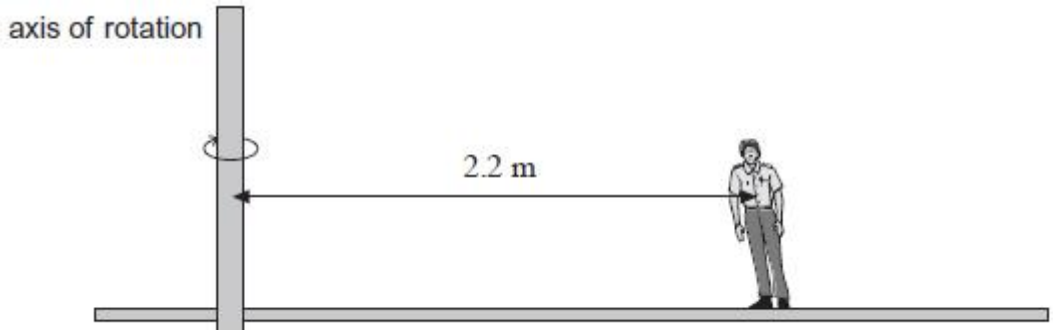
(3)

(ii) Calculate the number of revolutions that are made before the roundabout comes to rest.

number of revolutions _____

(3)

(c) An operator of mass 65 kg is standing on the roundabout when the roundabout is rotating at an angular velocity of 0.47 rad s^{-1}. His centre of mass is 2.2 m from the axis of rotation. The diagram shows that his body leans towards the centre of the path.



(i) Calculate the centripetal force needed for the operator to remain at this radius on the roundabout.

centripetal force _____ N

(2)

(ii) State the origin of this centripetal force and suggest why the operator has to incline his body towards the centre of rotation to avoid falling over.

You may draw the forces that act on the operator in the diagram to help your answer.

_____

_____

_____

_____

_____

(2)

(iii) While the roundabout is moving, the operator drops a coin.

Which statement correctly describes and explains what happens to the coin?
Tick (✔) the correct answer in the right-hand column.

	Tick (✔)
There is no longer a centripetal force acting, so the coin falls vertically downwards and lands on the roundabout directly below the point at which it was dropped.	
The centripetal force causes the coin to have a horizontal component of velocity towards the centre of the roundabout, so that it follows a trajectory towards the centre of the roundabout.	
There is no longer a centripetal force acting, so there is a horizontal component of the coin's velocity directed away from the centre of the roundabout and it follows a trajectory directly away from the centre.	

There is no longer a centripetal force acting, so the coin has a horizontal component of its velocity tangential to its original path on the roundabout and it follows a trajectory along this tangent.	

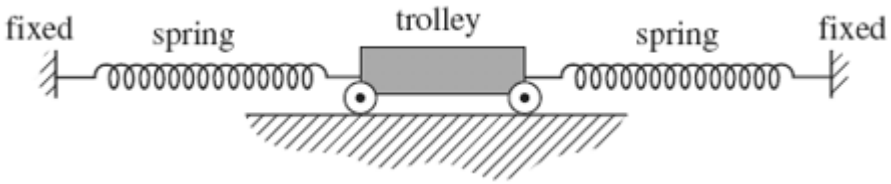
(1)

(Total 14 marks)

Q2.

A trolley of mass 0.80 kg rests on a horizontal surface attached to two identical stretched springs, as shown in **Figure 1**. Each spring has a spring constant of $30 Nm^{-1}$, can be assumed to obey Hooke's law, and to remain in tension as the trolley moves.

Figure 1



(a) (i) The trolley is displaced to the left by 60 mm and then released. Show that the magnitude of the resultant force on it at the moment of release is 3.6 N.

(2)

(ii) Calculate the acceleration of the trolley at the moment of release and state its direction.

answer = _____ $m\ s^{-2}$

direction _____

(2)

(b) (i) The oscillating trolley performs simple harmonic motion. State the **two** conditions which have to be satisfied to show that a body performs simple harmonic motion.

_____

_____

_____

_____

_____

_____

(2)

(ii) The frequency f of oscillation of the trolley is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{2k}{m}}$$

where m = mass of the trolley

k = spring constant of one spring.

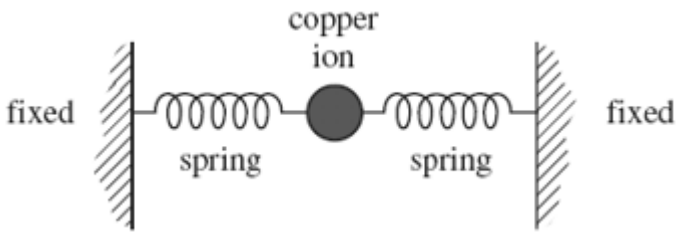
Calculate the period of oscillation of the trolley, stating an appropriate unit.

answer = _____

(3)

(c) Copper ions in a crystal lattice vibrate in a similar way to the trolley, because the inter-atomic forces act in a similar way to the forces exerted by the springs. **Figure 2** shows how this model of a vibrating ion can be represented.

Figure 2



(i) The spring constant of each inter-atomic 'spring' is about 200Nm^{-1}. The mass of the copper ion is 1.0×10^{-25} kg. Show that the frequency of vibration of the copper ion is about 10^{13} Hz.

(1)

(ii) If the amplitude of vibration of the copper ion is 10^{-11}m, estimate its maximum speed.

answer = _____m s^{-1}

(1)

(iii) Estimate the maximum kinetic energy of the copper ion.

answer = _____J

(1)

(Total 12 marks)