Circular Motion – 2021/20 GCE Physics A Component 01

1. Nov/2021/Paper_H556_01/No.22

(a) The diagram below shows the Earth in space.

(i) On the diagram above, draw a minimum of **four** gravitational field lines to map out the gravitational field pattern around the Earth. **[1]**

(ii) On the same diagram above, show **two** different points where the gravitational potential is the same. Label these points **X** and **Y**. **[1]**

(b)* A satellite is in a circular geostationary orbit around the centre of the Earth. The satellite has both kinetic energy and gravitational potential energy.

The mass of the satellite is 2500 kg and the radius of its circular orbit is 4.22×10^7 m.
The mass of the Earth is 5.97×10^{24} kg.

- Describe some of the features of a geostationary orbit.
- Calculate the **total** energy of the satellite in its geostationary orbit. **[6]**

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Additional answer space if required.

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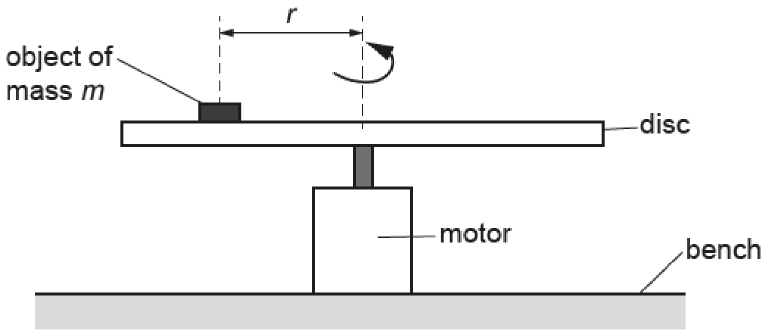
2. Nov/2020/Paper_H556_01/No.20

A small object of mass m is placed on a rotating horizontal metal disc at a distance r from the centre of the disc.



The frequency of rotation is adjusted using a motor attached to the disc.

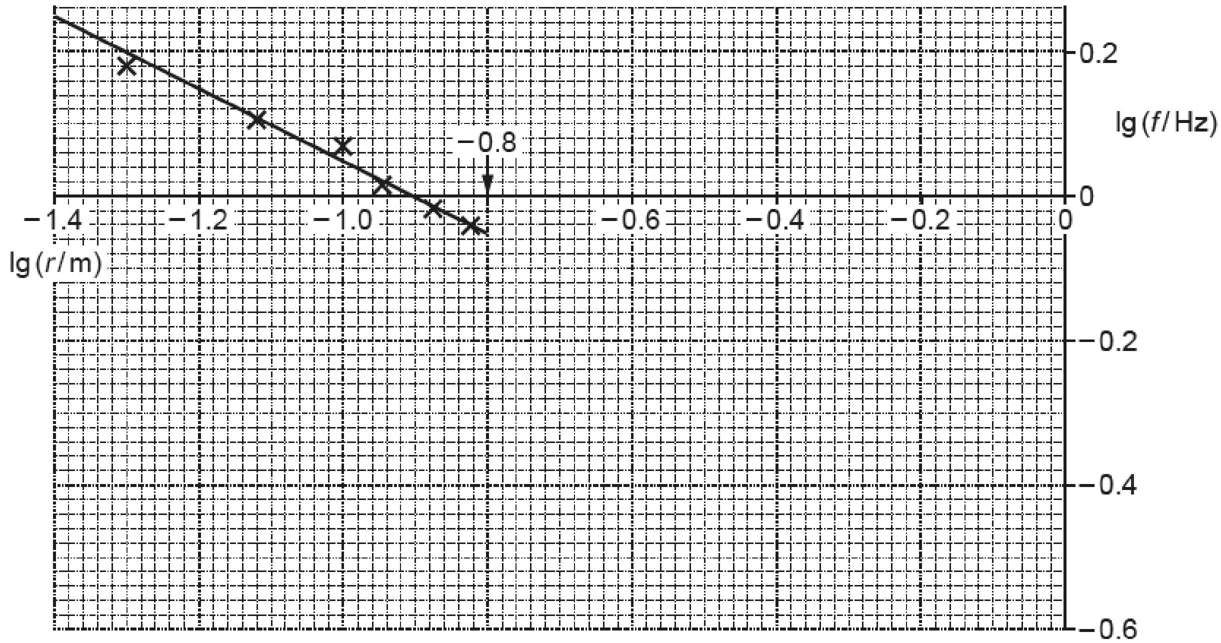
The frequency of rotation of the disc is slowly increased from zero, until the object slips off. At this point, the friction F acting on the object is equal to the centripetal force.

The friction F is given by the expression $F = kmg$, where k is a constant and g is the acceleration of free fall. The constant k has no units.

(a) Show that the frequency f at which the object slips off is given by the equation $f^2 = \left(\frac{gk}{4\pi^2}\right) \times \frac{1}{r}$.

[3]

(b) A student plots a graph of lg (f/Hz) against lg (r/m).



For this graph: y-intercept = $\frac{1}{2} \times \lg\left(\frac{gk}{4\pi^2}\right)$

Use the graph to determine the constant k. Write your answer to 2 significant figures.

k = ... **[4]**

3. Nov/2021/Paper_H556_03/No.6

The London Eye, shown rotating anticlockwise in **Fig. 6.1**, is a giant wheel which rotates slowly at a constant speed.

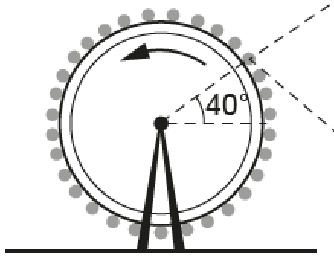


Fig. 6.1

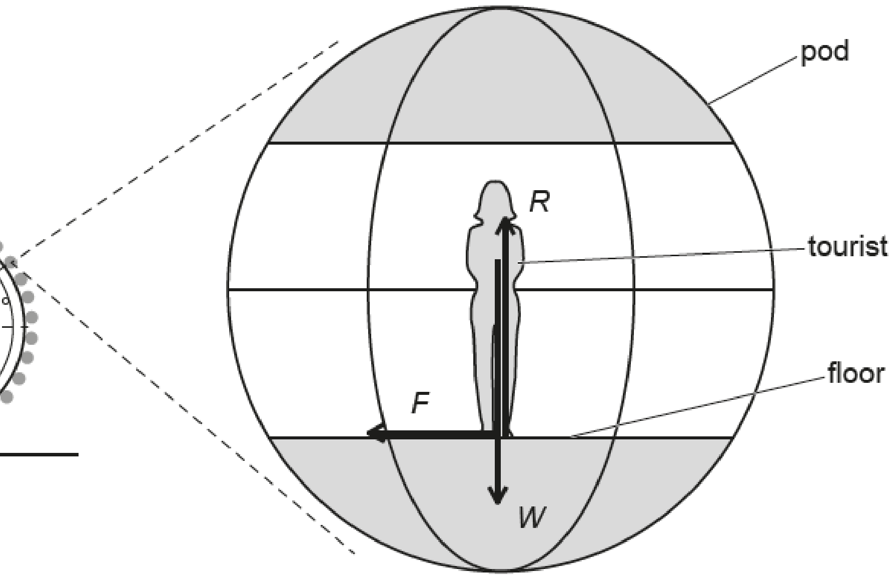


Fig. 6.2

Tourists stand in pods around the circumference of the wheel.
The floor remains horizontal at all times.
At time $t = 0$, a tourist who has a weight W of 650 N enters a pod at the bottom of the wheel.
Fig. 6.2 shows the forces acting on the tourist at a later time, when the angle between the pod's position and the centre of the wheel is 40° above the horizontal. R is the normal contact force and F is friction.

(a) The resultant upward force ($R - W$) on the tourist changes during the 30 minutes of the rotation of the London Eye as shown in **Fig. 6.3**.

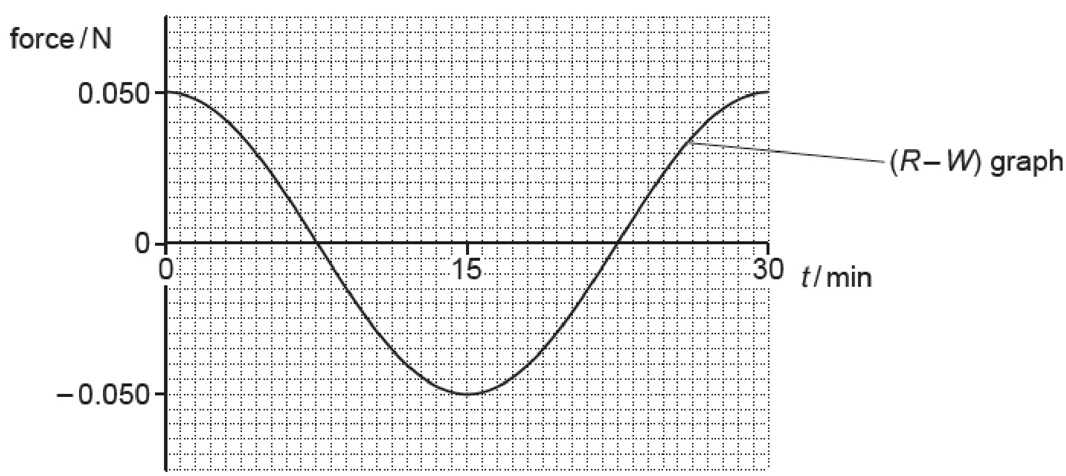


Fig. 6.3

Explain how the graph in **Fig. 6.3** shows that the magnitude of the centripetal force on the tourist during the rotation is 0.050 N.

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(b) **(i)** Explain why the horizontal force *F* between the floor and the tourist is necessary.

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.... **[2]**

(ii) Draw on **Fig. 6.3** the variation of the horizontal force *F* during the 30 minutes of the anticlockwise rotation of the London Eye. Take forces to the right to be positive. **[2]**

(iii) Calculate the magnitude of force *F* when the pod is at the position shown in **Fig. 6.2**, at 40° above the horizontal.

F = ... N **[2]**

(c) Calculate the distance *d* of the centre of mass of the tourist from the centre of rotation of the London Eye.

d = ... m **[3]**