Motion in a Circle

Question paper 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Motion in a circle
Sub Topic	
Paper Type	Theory
Booklet	Question paper 2

Time Allowed: **47 minutes**

Score: **/39**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 (a) (i) Define the *radian*.

.....

.....

..... [2]

(ii) A small mass is attached to a string. The mass is rotating about a fixed point P at constant speed, as shown in Fig. 1.1.

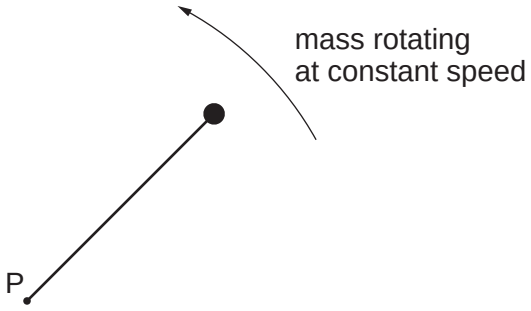

Fig. 1.1

Explain what is meant by the *angular* speed about point P of the mass.

.....

.....

..... [2]

(b) A horizontal flat plate is free to rotate about a vertical axis through its centre, as shown in Fig. 1.2.

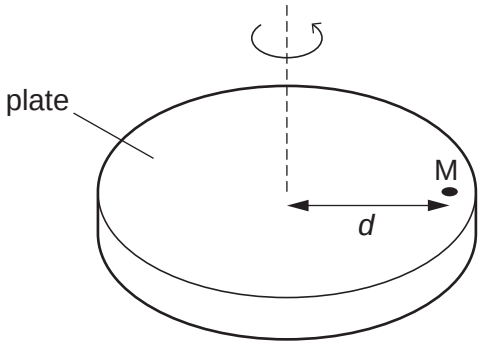

Fig. 1.2

A small mass M is placed on the plate, a distance *d* from the axis of rotation.
The speed of rotation of the plate is gradually increased from zero until the mass is seen to slide off the plate.

The maximum frictional force *F* between the plate and the mass is given by the expression

$$F = 0.72W,$$

where *W* is the weight of the mass M.
The distance *d* is 35 cm.

Determine the maximum number of revolutions of the plate per minute for the mass M to remain on the plate. Explain your working.

number = ...[5]

(c) The plate in **(b)** is covered, when stationary, with mud.
Suggest and explain whether mud near the edge of the plate or near the centre will first leave the plate as the angular speed of the plate is slowly increased.

.....

.....

.....[2]

2 **(a)** Explain

(i) what is meant by a *radian*,

.....

.....

.....[2]

(ii) why one complete revolution is equivalent to an angular displacement of 2π rad.

.....

.....[1]

(b) An elastic cord has an unextended length of 13.0 cm. One end of the cord is attached to a fixed point C. A small mass of weight 5.0 N is hung from the free end of the cord. The cord extends to a length of 14.8 cm, as shown in Fig. 1.1.

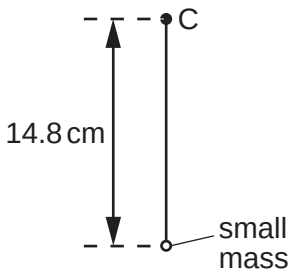

Fig. 1.1

The cord and mass are now made to rotate at constant angular speed ω in a vertical plane about point C. When the cord is vertical and above C, its length is the unextended length of 13.0 cm, as shown in Fig. 1.2.

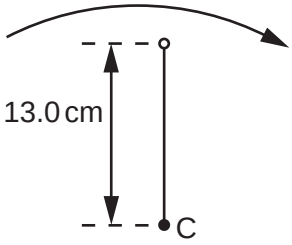

Fig. 1.2

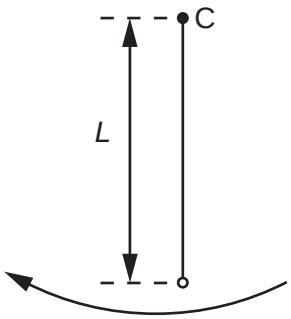

Fig. 1.3

(i) Show that the angular speed ω of the cord and mass is 8.7 rad s^{-1}.

[2]

(ii) The cord and mass rotate so that the cord is vertically below C, as shown in Fig. 1.3.

Calculate the length *L* of the cord, assuming it obeys Hooke's law.

L = ... cm [4]

3 The orbit of the Earth, mass 6.0×10^{24} kg, may be assumed to be a circle of radius 1.5×10^{11} m with the Sun at its centre, as illustrated in Fig. 1.1.

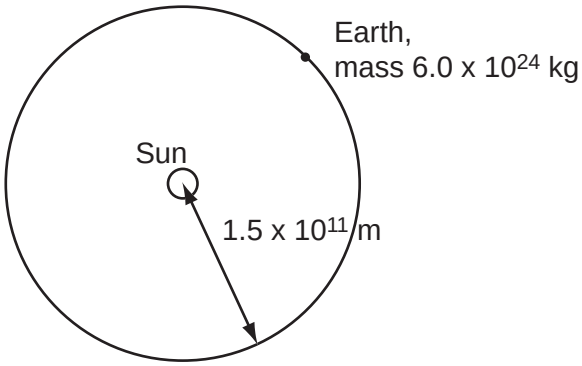

Fig. 1.1

The time taken for one orbit is 3.2×10^{7} s.

(a) Calculate

(i) the magnitude of the angular velocity of the Earth about the Sun,

angular velocity = ... rad s^{-1} [2]

(ii) the magnitude of the centripetal force acting on the Earth.

force = ... N [2]

(b) (i) State the origin of the centripetal force calculated in **(a)(ii)**.

.....

.....[1]

(ii) Determine the mass of the Sun.

mass = ... kg [3]

4 A particle is following a circular path and is observed to have an angular displacement of 10.3°.

(a) Express this angle in radians (rad). Show your working and give your answer to three significant figures.

angle = ...rad [2]

(b) **(i)** Determine tan10.3° to three significant figures.

tan10.3° = ...

(ii) Hence calculate the percentage error that is made when the angle 10.3°, as measured in radians, is assumed to be equal to tan10.3°.

percentage error = ...
[3]

5 A proton of mass *m* and charge +*q* is travelling through a vacuum in a straight line with speed *v*.
It enters a region of uniform magnetic field of magnetic flux density *B*, as shown in Fig. 4.1.

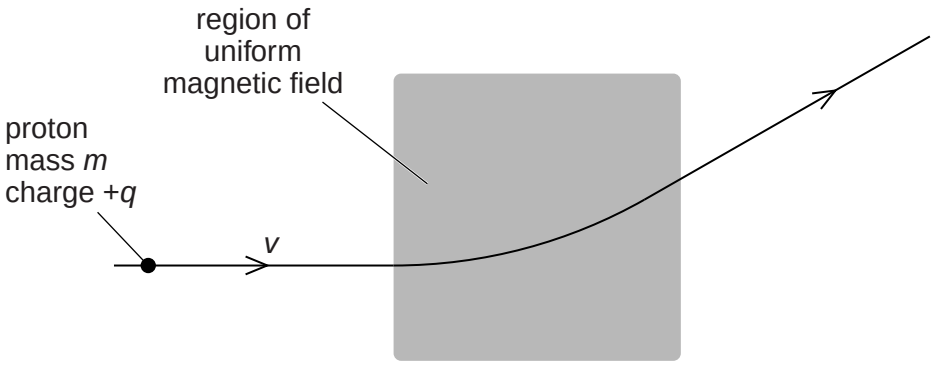

Fig. 4.1

The magnetic field is normal to the direction of motion of the proton.

(a) Explain why the path of the proton in the magnetic field is an arc of a circle.

.....

.....

.....[2]

(b) The angular speed of the proton in the magnetic field is ω.
Derive an expression for ω in terms of *B*, *q* and *m*.

[4]