AQA
Realising potential

TOPIC TEST

A-level FURTHER MATHS

Circular Motion

Version 1.0

Specification content coverage: MD4, MD5, MD6

In this test you will be assessed on:

- use of position, velocity and acceleration vectors in horizontal circular motion
- the conical pendulum
- appropriate contextual questions involving horizontal circular motion testing understanding of assumptions
- circular motion in a vertical plane
- resolving forces towards the centre of a vertical circle
- understanding of when an object completes a vertical circle

The test comprises two sections. The questions in section A will test you on the basics of the topic. Those in section B require a bit more thinking.

Section A: The basics

1 John is skating around an ice rink with a constant speed of 10 m s^{-1}.

He moves in a circle of radius 5 m.

Find the magnitude of his acceleration.

[1 mark]

2 The Earth has a radius of 6400 km and can be modelled as rotating with an angular speed of 7.3 x 10^{-5} radians per second.

Find the magnitude of the acceleration of a person standing on the Equator

[1 mark]

3 Elizabeth runs around a circular path on horizontal ground in a park.

Her motion can be modelled by $\mathbf{r} = 12\cos\frac{\pi}{6}t\mathbf{i} + 12\sin\frac{\pi}{6}t\mathbf{j}$ metres

Find the exact magnitude of her acceleration.

[4 marks]

4 A coin is on a rough horizontal turntable at a distance of 0.4 m from the centre.

The turntable rotates at a constant angular speed.

The coefficient of friction between the coin and the turntable is 0.2.

Given that the coin does not slip, and assuming g = 9.8 m s^{-2}, find the maximum angular speed of the turntable.

[4 marks]

5 A smooth circular wire of radius r and centre *O* is fixed in a vertical plane.

A bead of mass 0.3 kg is threaded on the wire.

The bead is set in motion with speed u from the lowest point on the circular wire.

Given that the bead makes a complete vertical circle, show that

$$u > 2\sqrt{rg}$$

[4 marks]

Section B: A bit more thinking

6 A pilot, of mass 70 kg, is performing an aircraft manoeuvre at an air show.

She flies the aircraft in a vertical circle of radius 350 m.

At the top of the circle the aircraft is flying upside down with a speed of 35 m s^{-1}.

Assuming that g = 9.81 m s^{-2}, find the magnitude of the reaction between the pilot and the aircraft at the top of the circle.

[4 marks]

7 (a) A particle, *P*, of mass 4 kg is attached to one end of a light inextensible string.

The string passes through a small, fixed smooth ring *O*.

A second particle, *Q*, of mass 6 kg is attached to the other end of the string.

Q hangs at rest vertically below *O*.

P moves with speed 5 m s^{-1} in a horizontal circle of radius r.

Find the acute angle between *OP* and the vertical.

[4 marks]

7 (b) Find r.

[3 marks]

8 (a) Martin, who has mass 70 kg, is sitting on the seat of a swing.

The swing is made from ropes which are 2 m in length.

Jo-Jo holds the seat so that the ropes are at an angle of 30^{o} to the vertical and then releases it.

Model Martin as a particle and the ropes as light and inextensible and assume g = 9.8 m s^{-2}.

Find Martin's maximum speed in the subsequent motion.

[5 marks]

8 (b) Explain, giving a reason, whether your answer in **(a)** is likely to be an underestimate or an over estimate of Martin's actual maximum speed.

[2 marks]