# 6.1 Circular Motion

## Question Paper

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| Course | DP IB Physics |
| Section | 6. Circular Motion & Gravitation |
| Topic | 6.1 Circular Motion |
| Difficulty | Medium |

**Time allowed:** 60

**Score:** /49

**Percentage:** /100

## Question 1a

A lead ball of mass 0.55 kg is swung round on the end of a string so that the ball moves in a horizontal circle of radius 1.5 m. The ball travels at a constant speed of 6.2 m $s^{-1}$.

(a)
Calculate the time taken for the string to turn through an angle of 170°.

**[3 marks]**

## Question 1b

(b)
Calculate the tension in the string.

**[2 marks]**

## Question 1c

The string will break when the tension exceeds a maximum tension. The ball makes three revolutions per second at the maximum tension of the string.

(c)
Calculate the tension above which the string will break.

**[2 marks]**

## Question 1d

(d)
Describe, using just one of Newton's Laws, why the ball is accelerating even when its angular speed is constant.

You may wish to draw a diagram to clarify your answer.

**[3 marks]**

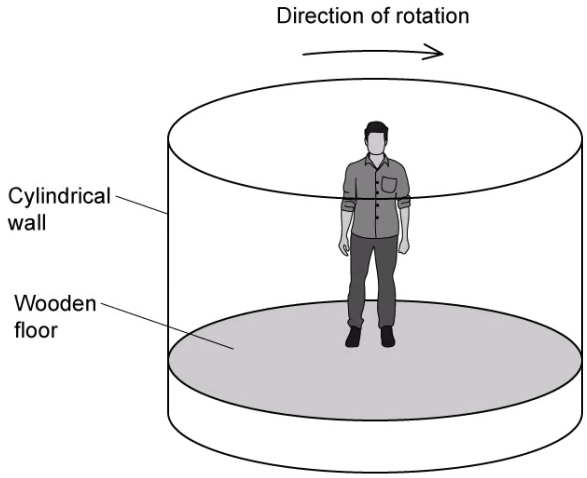
## Question 2a

(a)
Explain why a particle moving in a circle with uniform speed is accelerating.

**[2 marks]**

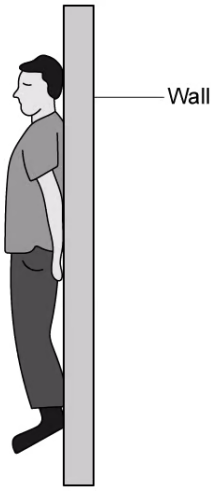
## Question 2b

The diagram shows a fairground ride called a Rotor. Riders stand on a wooden floor and lean against the cylindrical wall.




The fairground ride is then rotated. When the ride is rotating sufficiently quickly the wooden floor is lowered. The riders remain pinned to the wall by the effects of the motion. When the speed of rotation is reduced, the riders slide down the wall and land on the floor.

At the instant shown in below the ride is rotating quickly enough to hold a rider at a constant height when the floor has been lowered.




(b)
Explain why the riders slide down the wall as the ride slows down.

**[2 marks]**

## Question 2c

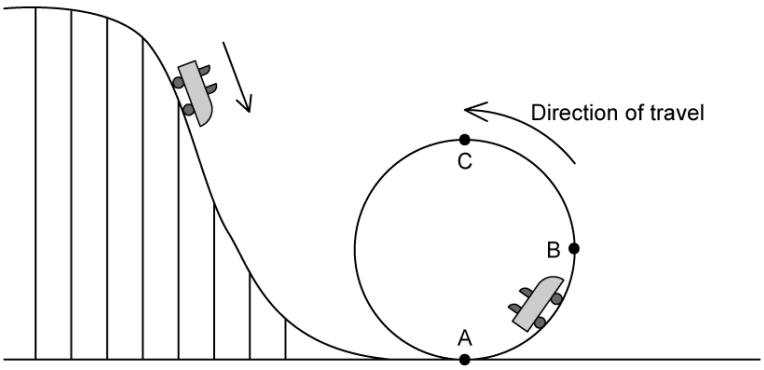
A rotor accelerates uniformly from rest to maximum angular velocity of 3.6 rads $s^{-1}$. At the maximum speed the centripetal acceleration is 35 m $s^{-2}$.

(c)
Calculate the diameter of the rotor.

**[2 marks]**

## Question 2d

The diagram shows the final section of a roller coaster which ends in a vertical loop. Cars on the roller coaster descend to the start of the loop and then travel around it.



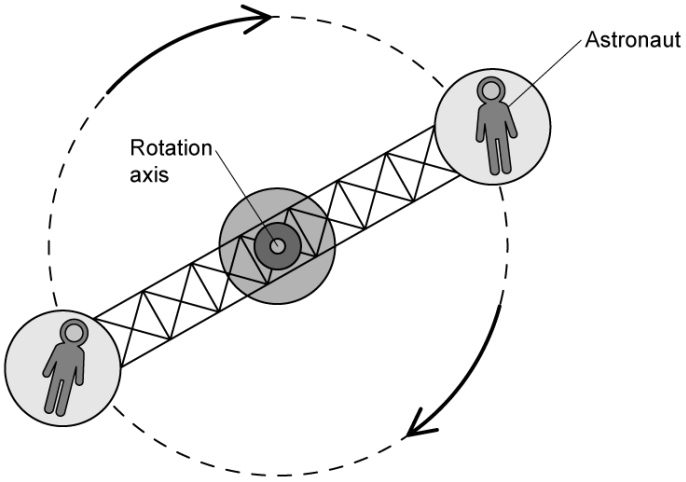

As the passengers move around the circle from **A** to **B** to **C**, the reaction force between exerted by their seat varies.

(d)
State the position at which this force will be a maximum and the position at which it will be a minimum. Explain your answers.

**[4 marks]**

## Question 3a

A centrifuge is often used in astronaut training. This is to simulate Earth's gravity on board the space station. The astronauts sit in a cockpit at the end of each arm, each rotating about an axis at the centre.




At its top speed, the centrifuge makes 1 full rotation every 2.30 s.

(a)
Calculate the frequency of the centrifuge. State an appropriate unit and express your answer to an appropriate number of significant figures.

**[3 marks]**

## Question 3b

(b)
Calculate the angular speed of the centrifuge in rad $s^{-1}$.

**[2 marks]**

## Question 3c

Each astronaut is placed 6.30 m from the rotation axis.

(c)
Calculate the magnitude of the centripetal acceleration on each astronaut.

**[2 marks]**

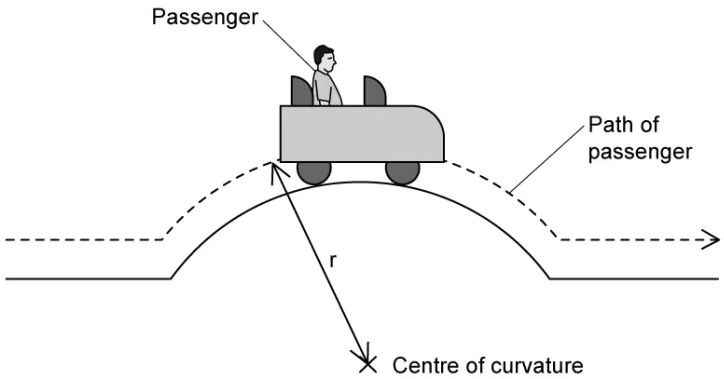
## Question 3d

(d)
Sketch the direction of the acceleration on each astronaut.

**[1 mark]**

## Question 4a

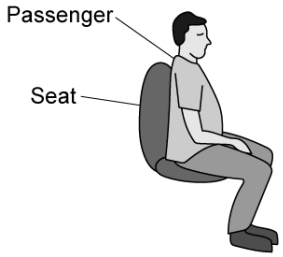
A section of a roller coaster carries a passenger over a curve in the track. The radius of curvature of the path of the passenger is $r$ and the roller coaster is travelling at constant speed $v$. The mass of the passenger is $m$.




(a)

(i)
Draw the forces that act on the passenger as they pass over the highest point on the curved track.

(ii)
Write down an equation that relates the contact force $R$ between the passenger and the seat to $m$, $v$, $r$ and the gravitational field strength, $g$.




**[2 marks]**

## Question 4b

At a particular point on the track, the car moves with a linear velocity of 22 m $s^{-1}$. The reaction force between the car and the track at this point is 210 N and the passenger has a mass of 65 kg.

(b)
Calculate the distance from the passenger to the centre of curvature of the curved track.

**[3 marks]**

## Question 4c

(c)
State and explain what would happen to the magnitude of *R* if the rollercoaster passed over the curved track at a higher speed.

**[2 marks]**

## Question 4d

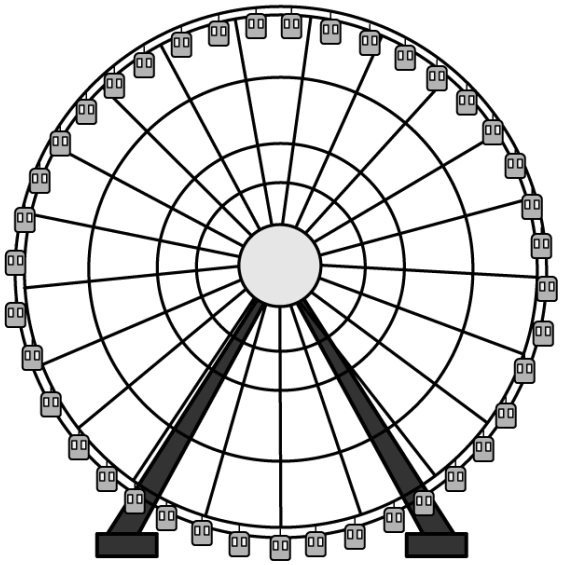
When the rollercoaster passes over a curved section of a track above a certain speed, the passenger is momentarily lifted off their seat and experiences weightlessness.

(d)
Calculate the speed at which the rollercoaster must be travelling for the passenger to experience weightlessness.

**[3 marks]**

## Question 5a

The London Eye shown in the diagram has a radius of approximately 68 m and the passengers in the capsules travel at an angular speed of $3.5 \times 10^{-3}$ rad $s^{-1}$.



(a)
Calculate the speed of each passenger in the capsules.

**[2 marks]**

## Question 5b

Assume the London Eye is rotating clockwise.

(b)
Sketch the following on any capsule:

(i) The direction of the centripetal force *F*

(ii) The direction of the linear speed *v*.

**[2 marks]**

## Question 5c

Each capsule weighs about 98.1 kN.

(c)
Calculate the centripetal force on an empty capsule.

**[3 marks]**

## Question 5d

Dan has travelled to London to watch an exciting Physics show. Being an eager tourist, he arrives early and plans to ride the London Eye. When he gets to the front of the queue however, he realises he only had 40 minutes before he needs to leave for the show.

(d)
State, with a calculation, whether Dan is still able to ride the London Eye and leave to see the show on time.

**[4 marks]**