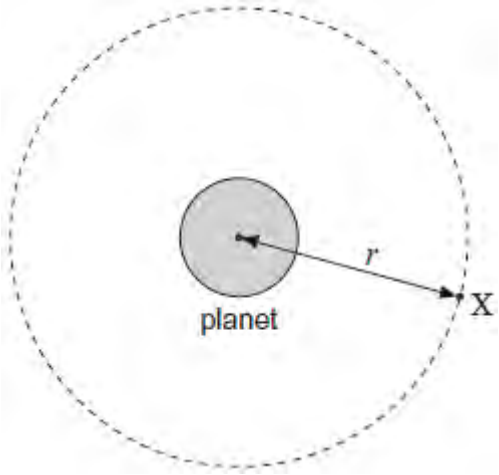
Q1. A satellite X is in a circular orbit of radius r about the centre of a spherical planet of mass M.



Which line, **A** to **D**, in the table gives correct expressions for the centripetal acceleration a and the speed v of the satellite?

	Centripetal acceleration a	**Speed v**
A	$\frac{GM}{2r}$	$\sqrt{\frac{GM}{2r}}$
B	$\frac{GM}{2r}$	$\sqrt{\frac{GM}{r}}$
C	$\frac{GM}{r^2}$	$\sqrt{\frac{GM}{2r}}$
D	$\frac{GM}{r^2}$	$\sqrt{\frac{GM}{r}}$

(Total 1 mark)

Q2. A lead ball of mass 0.25 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 8.6 m s^{-1}.

(a) (i) Calculate the angle, in degrees, through which the string turns in 0.40 s.

angle ..... degree

(3)

(ii) Calculate the tension in the string.
You may assume that the string is horizontal.

tension ..... N

(2)

(b) The string will break when the tension exceeds 60 N.
Calculate the number of revolutions that the ball makes in one second when the tension is 60 N.

number of revolutions .....

(2)

(c) Discuss the motion of the ball in terms of the forces that act on it. In your answer you should:

- explain how Newton's three laws of motion apply to its motion in a circle
- explain why, in practice, the string will not be horizontal.

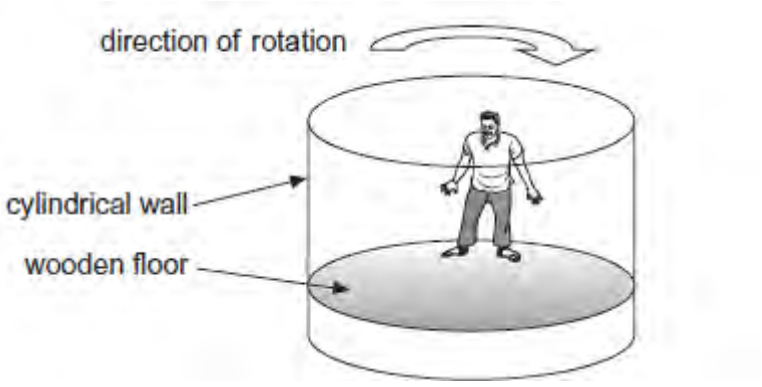
You may wish to draw a diagram to clarify your answer.

The quality of your written communication will be assessed in your answer.

(6)
(Total 13 marks)

Q3.Figure 1 shows a fairground ride called a Rotor. Riders stand on a wooden floor and lean against the cylindrical wall.

Figure 1



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.

(a) (i) At the instant shown in **Figure 2** the ride is rotating quickly enough to hold a rider at a constant height when the floor has been lowered.

Figure 2

Draw onto **Figure 2** arrows representing all the forces on the rider when held in this position relative to the wall.
Label the arrows clearly to identify all of the forces.

(3)

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

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.....

.....

(2)

A Rotor has a diameter of 4.5 m. It accelerates uniformly from rest to maximum angular velocity in 20 s.
The total moment of inertia of the Rotor and the riders is 2.1×10^5 kg m^2.

(b) (i) At the maximum speed the centripetal acceleration is 29 m s^{-2}.

Show that the maximum angular velocity of a rider is 3.6 rad s^{-1}.

(2)

(ii) Calculate the torque exerted on the Rotor so that it accelerates uniformly to its maximum angular velocity in 20 s.
State the appropriate SI unit for torque.

torque ..... SI unit for torque .....

(3)

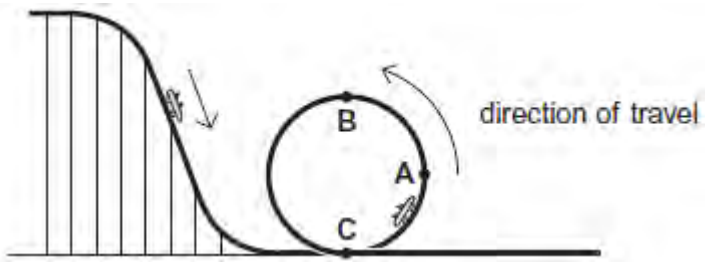
(iii) Calculate the centripetal force acting on a rider of mass 75 kg when the ride is moving at its maximum angular velocity.
Give your answer to an appropriate number of significant figures.

centripetal force ..... N

(1)

(c) **Figure 3** shows the final section of a roller coaster which ends in a vertical loop. The roller coaster is designed to give the occupants a maximum acceleration of $3g$. Cars on the roller coaster descend to the start of the loop and then travel around it, as shown.

Figure 3



(i) At which one of the positions marked **A**, **B** and **C** on **Figure 3** would the passengers experience the maximum reaction force exerted by their seat? Circle your answer below.

A **B** **C**

(1)

(iii) Explain why the maximum acceleration is experienced at the position you have chosen.

.....

.....

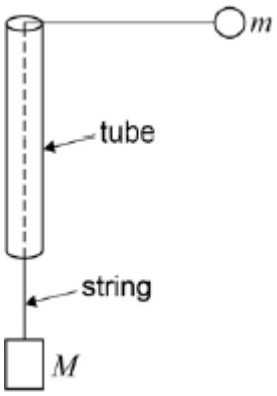
.....

.....

(2)

(Total 14 marks)

Q4. A string passes through a smooth thin tube. Masses m and M are attached to the ends of the string. The tube is moved so that the mass m travels in a horizontal circle of constant radius r and at constant speed v.



Which of the following expressions is equal to M ?

A $\frac{mv^2}{2r}$ ⬭

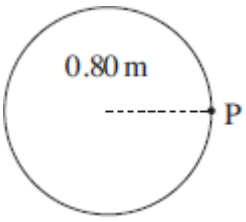
B mv^2rg ⬭

C $\frac{mv^2}{rg}$ ⬭

D $\frac{mv^2g}{r}$ ⬭

(Total 1 mark)

Q5. A model car moves in a circular path of radius 0.80 m at an angular speed of $\frac{\pi}{2}$ rad s^{-1}.



What is its displacement from point P 6.0 s after passing P?

A zero

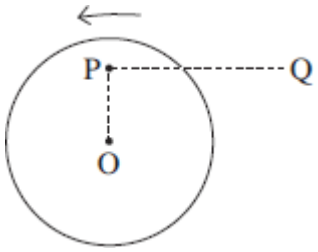
B 0.4π m

C 1.6 m

D 1.6π m

(Total 1 mark)

Q6. A small mass is placed at P on a horizontal disc which has its centre at O. The disc rotates anti-clockwise about a vertical axis through O with constant angular speed.



Which one of the following describes the force which keeps the mass at rest relative to the disc when in the position shown?

A the weight of the mass

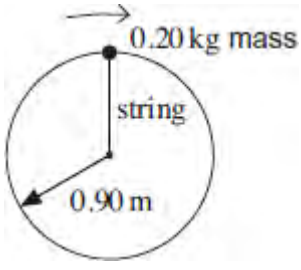
B a frictional force from P to Q

C a frictional force directed away from O

D a frictional force directed towards O

(Total 1 mark)

Q7. A 0.20 kg mass is whirled round in a vertical circle on the end of a light string of length 0.90 m.



At the top point of the circle the speed of the mass is 8.2 m s^{-1}. What is the tension in the string at this point?

A 10 N

B 13 N

C 17 N

D 20 N

(Total 1 mark)

Q8. The wheel of the London Eye has a diameter of 130 m and rotates at a steady speed, completing one rotation every 30 minutes. What is the centripetal acceleration of a person in a capsule at the rim of the wheel?

A 1.2×10^{-4} ms^{-2}

B 2.5×10^{-4} ms^{-2}

C 3.9×10^{-4} ms^{-2}

D 7.9×10^{-4} ms^{-2}

(Total 1 mark)

Q9. A small body of mass m rests on a horizontal turntable at a distance *r* from the centre. If the maximum frictional force between the body and the turntable is $\frac{mg}{2}$, what is the angular speed at which the body starts to slip?

A $\sqrt{\frac{gr}{2}}$

B $\frac{g}{r}$

C $\sqrt{\frac{g}{2r}}$

D $\frac{1}{2}\sqrt{\frac{g}{r}}$

(Total 1 mark)

Q10. A body of mass 0.50 kg, fixed to one end of a string, is rotated in a vertical circle of radius 1.5 m at an angular speed of 5.0 rad s^{-1}. What is the maximum tension in the string?

A 5.0 N

B 9.0 N

C 14 N

D 24 N

(Total 1 mark)