

CIRCULAR MOTION

Challenging **MCQ** questions by The Physics Cafe

Compiled and selected by **The Physics Cafe**



- 1 A car is making a turn at speed v . The radius of the turn is r and the centripetal force on the car is F .
If the car rounds the same curve at speed $2v$, the required centripetal force is

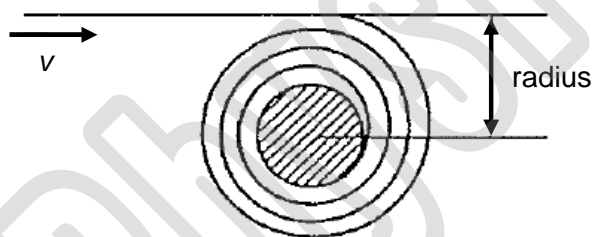
- A $\frac{1}{2}F$ B F C $2F$ D $4F$

- 2 A body of mass m moves in a horizontal circle of radius r at constant speed v for one complete revolution.

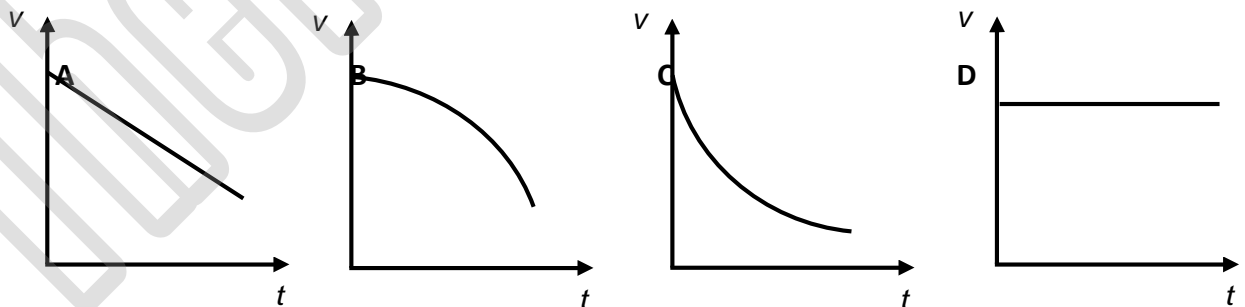
Which of the following statements is incorrect?

- A The angular velocity of body is directed perpendicular to the plane of circular motion.
B The work done by the centripetal force is $2\pi mv^2$.
C The change in linear momentum of the body is zero.
D The total energy of the body is constant.

- 3 A straight length of tape unwinds from a roll rotating about a fixed axis with constant angular velocity, the radius of the roll decreasing at a steady rate.

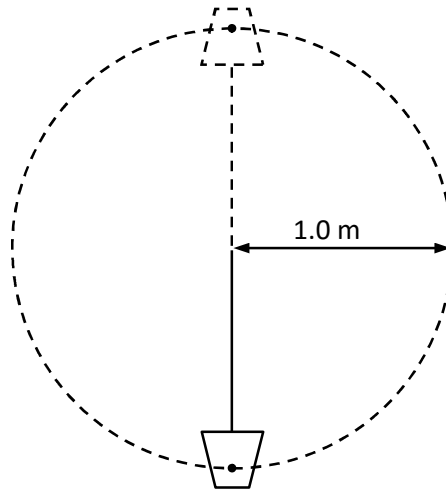


Which of the following graphs correctly shows how the variation of speed v at which the tape moves away from the roll with time t ?



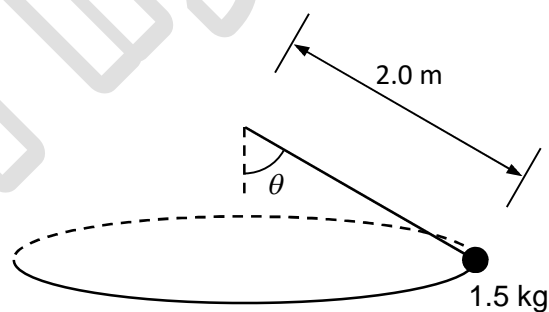
- 4 The clock on Big Ben has a minute hand of length 4.3 m and an hour hand of length 2.7 m. What is the ratio of the centripetal acceleration of a point on the tip of the minute hand to a point on the tip of the hour hand?
- A 1.6 B 150 C 230 D 5700
- 5 Which of the following statements is **not** true for a stone attached to a string and swung in a uniform vertical circular motion?
- A The magnitude of resultant force acting on the stone changes depending on the position of the stone in the circle.
- B The tension in the string is lowest when the stone is at the highest point of the circular motion.
- C The kinetic energy of the stone is constant throughout the entire circular motion.
- D The resultant acceleration is always directed towards the centre of the circle.

- 6 A light pail containing water is attached to a light rope and swung around in a vertical circle. The radius of the circular motion is 1.0 m. The water just manages to stay in the pail at the highest point of motion.



What is the linear speed of the pail at the lowest point of motion?

- A 3.13 m s⁻¹ B 5.42 m s⁻¹ C 7.00 m s⁻¹ D 7.87 m s⁻¹
- 7 A ball of mass 1.5 kg is attached to a light string of length 2.0 m and made to rotate in a horizontal circle.

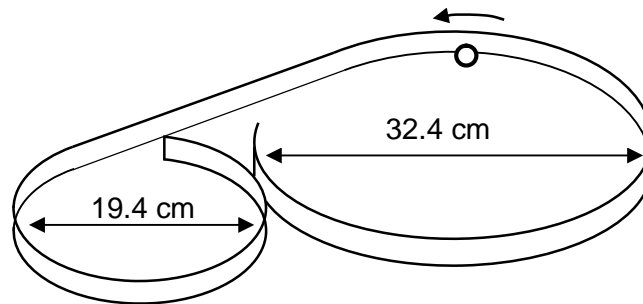


The string snaps when the linear speed of the ball reaches 12.0 m s⁻¹.

What is the maximum tension the string is able to withstand?

- A 18.9 N B 110 N C 217 N D 277 N

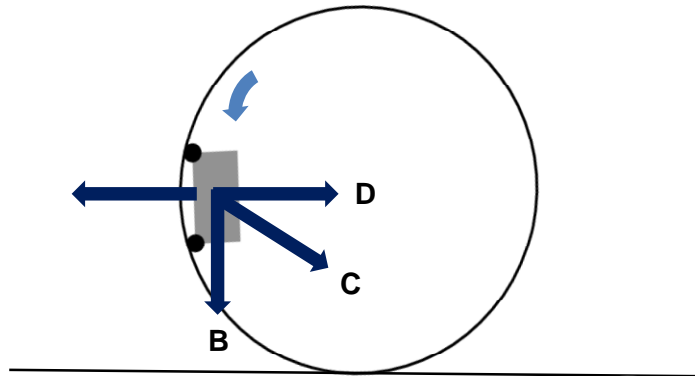
- 8 A small sphere is travelling horizontally around the circumference of the bigger circular loop in the figure below with an angular velocity of 63.0 rad s^{-1} .



The sphere then moves into the smaller loop and continues to move along its circumference. What will be the angular velocity of the sphere when it is moving in the smaller loop?

- A** 37.7 rad s^{-1} **B** 63.0 rad s^{-1} **C** 105 rad s^{-1} **D** 126 rad s^{-1}

- 9 The roller coaster car having just cleared the top of the loop is moving down a frictionless track at the moment shown in the diagram.



Which direction **A**, **B**, **C** or **D** is the net force acting on the car?

- 10 During the spin cycle of a washing machine, the clothes stick to the outer wall of the barrel as it spins at a rate of 1800 revolutions per minute about the vertical axis. The radius of the barrel is 36 cm.
- What is the magnitude and direction of centripetal acceleration of the clothes which are located on the wall of the barrel?

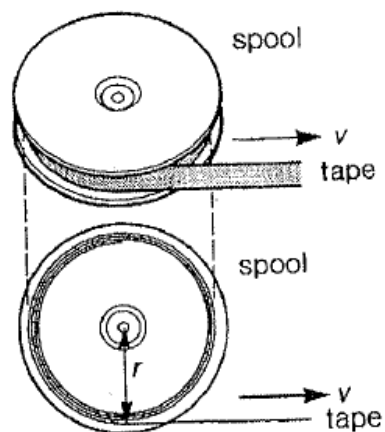
	magnitude	direction
A	$46.0 \times 10^6 \text{ m s}^{-2}$	towards the centre of the barrel
B	$46.0 \times 10^6 \text{ m s}^{-2}$	away from the centre of the barrel
C	$12.8 \times 10^3 \text{ m s}^{-2}$	towards the centre of the barrel
D	$12.8 \times 10^3 \text{ m s}^{-2}$	away from the centre of the barrel

- 11 The maximum safe speed of a car rounding an unbanked corner is 16 m s^{-1} when the road is dry. The maximum frictional force between the road surface and wheels of the car is halved when the road is wet.

What is the maximum safe speed for the car to round the corner when the road is wet?

- A 4.0 m s^{-1}
- B 6.0 m s^{-1}
- C 8.0 m s^{-1}
- D 11 m s^{-1}

- 12 In a tape cassette, the tape leaves one spool at a constant speed v and at a variable distance r from the centre.



Which of the following statements is true?

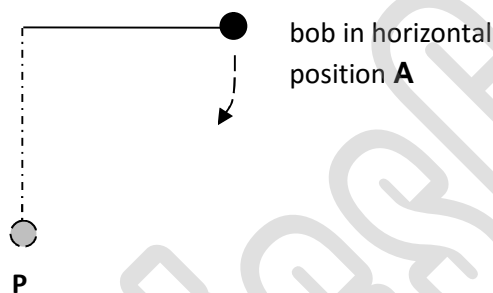
- A The angular velocity decreases as radius r decreases.
- B The angular velocity increases as radius r decreases.
- C The angular velocity is directly proportional to the speed v .
- D The angular velocity is directly proportional to the speed v^2 .

- 13 The combined mass of a race car and its driver is 600 kg. Travelling at constant speed, the car completes one lap around a circular track of radius 160 m in a total time of 36 s.

What is the magnitude of the centripetal acceleration of the car?

- A 0.17 m s^{-2} B 4.9 m s^{-2} C 100 m s^{-2} D 2900 m s^{-2}

- 14 A pendulum bob is released from rest in a horizontal position with the string taut.



Which of the following statements is correct when the pendulum reaches its vertical position at point P?

- A The tension attained its least value.
 B The tension depends only on the length of the pendulum.
 C The tension depends on the mass and length of the pendulum bob.
 D The magnitude of tension equals the weight of the pendulum bob.
- 15 A rock attached to a string swings in a vertical circle. At the highest point,
- A no forces act on the rock.
 B only one force acts on the rock.
 C two forces act on the rock and their resultant is zero.
 D two forces act on the rock and their resultant is not zero.

CIRCULAR MOTION WORKED SOLUTIONS

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1 Ans: **D**

Since $F_c = \frac{mv^2}{r}$, therefore the force will be 4 times.

2 Ans: **B**

A Correct. Using “right hand grip”, the direction of angular velocity is perpendicular to the plane of circular motion.

B Incorrect. The work done by the centripetal force is zero since centripetal force (ie resultant force) acting on the mass is always perpendicular to the displacement travelled by the mass.

C Correct. When the object is back to the same position in one complete revolution, the velocity is the same. Hence, change in linear momentum of the body is zero.

D Correct. The total energy (ie KE & GPE) of the body remains constant.

3 Ans: **A**

Using $v = r\omega$, since angular velocity ω remains constant, hence speed v varies proportionally with r , which decreases at a constant rate.

4 Ans: **C**

Since: $\omega = \frac{2\pi}{T}$ and $a_c = r\omega^2$

$$a_c = r\left(\frac{2\pi}{T}\right)^2$$

$$\frac{a_m}{a_h} = \frac{r_m / T_m^2}{r_h / T_h^2} = \frac{4.3 / 3600^2}{2.7 / (3600 \times 12)^2} = 230$$

5 Ans: **A**

In a uniform circular motion, the magnitude of the tangential velocity and the radius of the object remain constant. Therefore, since $F_c = \frac{mv^2}{r}$, the centripetal force which is the resultant force of the stone must remain the same.

6 Ans: **C**

7 Ans: **B**

8 Ans: **C**

9 Ans: **C**

The car is speeding up at that position and therefore it has a *tangential* component of the acceleration (*pointing downward*). At the same time, it is traveling in a circular path so it has a radial component of the acceleration *pointing towards the centre* of the circle. So the net force which is the sum of these two components is best represented by C

10 Ans : **C**

$$a_c = \omega^2 r = (2\pi f)^2 r$$

$$a_c = \left(2\pi \times \frac{1800}{60}\right)^2 0.36 = 12.8 \times 10^3 \text{ m s}^{-2}$$

Centripetal force is acting towards the centre of the barrel by the wall.

11 Ans: **D**

$$F_d = 2F_w$$

$$\frac{mv_d^2}{r} = 2 \frac{mv_w^2}{r}$$

$$\text{Since } v_d = 16 \text{ m s}^{-1},$$

$$v_w = \sqrt{\frac{16^2}{2}} = 11 \text{ m s}^{-1}$$

12 Ans: **B**

$v = r\omega$, where ω is the angular velocity.

$$\Rightarrow \omega = \frac{v}{r}$$

Since v is constant and r is decreasing, ω is increasing.

13 Ans: **B**

$$a_c = \frac{v^2}{r} = \frac{\left(\frac{2\pi r}{T}\right)^2}{r} = \frac{\left(\frac{2\pi(160)}{36}\right)^2}{160} = 4.9 \text{ m s}^{-2}$$

14 Ans: **C**

$$\text{At P, } T - W = F_c$$

$$T = F_c + mg$$

$$= mr\omega^2 + mg$$

\therefore tension depends on r (length of pendulum) and m (mass of bob)

15 Ans: **D**

Object is moving in circular motion, hence there must be a resultant force which is known as the centripetal force.

The two forces acting are tension and weight.