Past VCAA questions Circular motion Solutions

Multiple choice questions

Example 1 2008 Question 4, 65%

The car is moving in circular motion, therefore the net force must be radially inwards.

∴ ΣF_{net} is inwards

∴ **P (ANS)**

Example 2 2003 Question 11, 75%

For circular motion, the net force is always 'radially inwards'.

∴ **C (ANS)**

Example 3 2003 Question 13, 21%

The force that the 'tyre exerts on the road' is opposite to the force the 'road exerts on the tyre'. There are two forces that the road exerts on the tyre, the normal reaction and the frictional force that acts radially inwards. These two forces will sum to be 'H'.

∴ the answer is the opposite to 'H' which is "G"

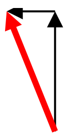
∴ **G (ANS)**

Example 4 2001 Question 10, 35%

At the lowest point, the roller coaster is in the bottom part of a section of circular motion. This means that the force causing this acceleration is directly up. If we now take friction and air resistance into consideration, (these will both be opposing the motion) then the net force is given by the sum of the two vectors.

∴ **E (ANS)**

Opposing forces



Central force

Examiners comment **Q10**

Arrow **E** best indicates the direction of the net force on the roller coaster car. The motion of the car at this point can be considered to be made up of both a uniform circular motion component (force towards the centre of the circle) and a friction component (force in the opposite direction to the motion).

Example 5 2000 Question 15, 52%

The net force is the centripetal force which is calculated by $F = m\frac{v^2}{r}$

$$F = 50 \times \frac{24^2}{12}$$

The magnitude of the net force is

$F = 2.4 \times 10^3 N$

The direction of the net force is always towards the centre of the radius.

$\therefore$ **C** **(ANS)**

Example 6 1981 Question 17, 61%

i P is moving in circular motion.
$\therefore$ net acceleration is radially inwards
$\therefore$ **A** **(ANS)**

ii P is moving in circular motion.
$\therefore$ net force is radially inwards
$\therefore$ **A** **(ANS)**

Example 7 1981 Question 18, 51%

i Q is moving in circular motion.
$\therefore$ net acceleration is radially inwards
$\therefore$ **A** **(ANS)**

ii Q is moving in circular motion.
$\therefore$ net force is radially inwards
$\therefore$ **A** **(ANS)**

Example 8 1979 Question 13, 51%

Kinetic energy is not a vector, therefore its direction is not required.
Momentum is a vector, therefore you need a direction to specify it completely.
Since the mass is moving in circular motion, its direction is constantly changing.
$\therefore$ KE is constant and "P" is changing
$\therefore$ **B** **(ANS)**

Non-uniform circular motion

Example 9 1985 Question 32, 33%

The total energy at point P (at the top) is the sum of the KE and the PE_P.

The $KE_P = ½mv^2$
$= ½ \times m \times gr$ (from Q31)
$PE_P = mgh$
$= m \times g \times 2r$

$\therefore$ At P the Energy = ½mgr + 2mgr
= 2½mgr.

This energy comes from the initial PE.

$\therefore$ mgh = 2.5mgr
$\therefore$ h = 2.5r
$\therefore$ **B** **(ANS)**

Example 10 1983 Question 18, 58%

When the car is at P, it has two components to its acceleration. One component is radially inwards, and the other is 2.0 ms^{-2} in the direction of motion.
$\therefore$ the net acceleration is between these two.
$\therefore$ **H** **(ANS)**

Example 11 1980 Question 23, 65%

When the bob passes through the point O, it has a net force acting radially inwards. In this case that means upwards. Therefore the tension needs to be greater than the weight, so that the net force is radially upwards

$\therefore$ **B (ANS)**

Example 12 1980 Question 24, 47%

If the bob is released from X', it will have greater PE, so it will have more KE at the point O.

The increase in KE will not be double, because the increase in PE isn't double.
Since the bob is travelling faster, it will require a greater force to keep in in circular motion.

$\therefore$ **B (ANS)**

Short answer questions

Example 13 2010 Question 1, 85%

Use $F = \frac{mv^2}{R}$ to get

$$11\,200 = \frac{700 \times v^2}{50}$$

$$\therefore v^2 = \frac{11200 \times 50}{700}$$

$$\therefore v^2 = 800$$

$\therefore$ **$v = 28.3$ m s^{-1} (ANS)**

Example 14 2010 Question 2, 86%

Use $a = \frac{v^2}{R}$ to get

$$F = \frac{28.28^2}{50}$$

$\therefore$ **$F = 16$ m s^{-2} (ANS)**

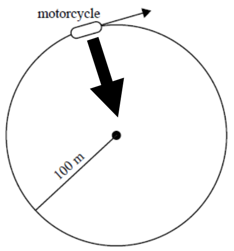
Example 15 2009 Question 3, 90%

Use $F = \frac{mv^2}{R}$ to get

$$F = \frac{250 \times 32.0^2}{100}$$

$\therefore$ **$F = 2560$ N (ANS)**

Example 16 2009 Question 4, 89%



The arrow needed to be radially inwards, from the centre of mass, looking like it was pointing to the centre of the circle.
You were either right or wrong, as there wasn't any 'half marks' for close enough.

Example 17 2008 Question 3, 80%

$$\Sigma F_{net} = T = \frac{mv^2}{r}$$
$$= \frac{2.4 \times 2^2}{1.6}$$
$$\mathbf{= 6\ N\ (ANS)}$$

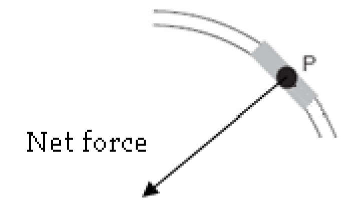
Example 18 2006 Question 4, 78%

If the rotor is moving just fast enough to stop Vivian slipping then
$F = W$
As $\Sigma F = 0$
$\therefore F = mg$
$= 60 \times 10$
= 600 N (ANS)
We won't worry too much about the stupidity of Vivienne having a **weight** of 60 kg, instead of 600 N.

Example 19 2006 Question 5, 65%

This is a very standard application of the formula
$$F = \frac{mv^2}{r}$$
The net force MUST be radially inwards (because it is circular motion)
$$\therefore F = \frac{60 \times 11^2}{\frac{15}{2}}$$
$\therefore$ **F = 968 N (ANS)**
(Be careful to use the radius not the diameter in your calculations)

Example 20 2005 Question 5, 76%



The net force is always radially inwards in circular motion. It is the force of the rails on the wheels that is providing this inwardly acting force.

Example 21 2005 Question 6, 35%

If the initial force is safe and F = $\frac{mv^2}{r}$

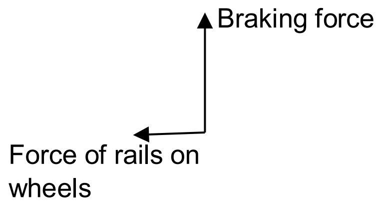
Then doubling the speed will require a fourfold increase in the radius. (because the speed is squared)

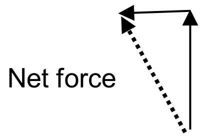
$\therefore$ 200 × 4 = **800 m (ANS)**

Example 22 2005 Question 7, 35%

There are now two forces acting, the radially inwards force from the rails, and the braking force from the brakes.

The braking force is opposing the motion therefore acting backwards.





$\therefore$ **B (ANS)**

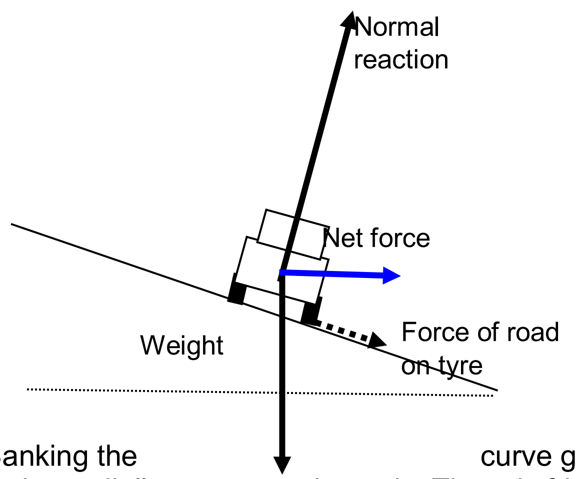
Example 23 2004 Question 10, 50%

To make it safer for trucks travelling around the bend you need to:

• increase the radius of the circular bend
• bank the curve
• lower the centre of gravity of the truck.

Since $F = m\frac{v^2}{r}$, if the radius is increased then for the same mass and speed the net force would decrease.

For the truck to go round the bend it needs a force acting radially inwards on it. This can be provided by either the friction from the road or a component of the normal reaction force.

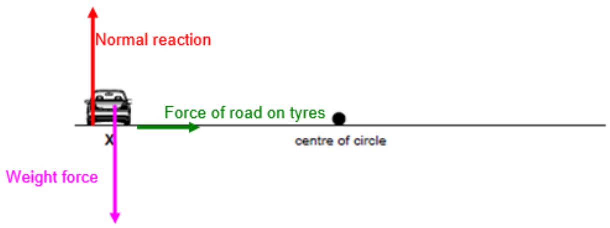


Banking the curve gives the Normal reaction force a component that is acting radially inwards. There is friction between the tyres and the road acting down the slope sideways. This friction force prevents the truck from sliding 'out' of the bend.

The normal reaction force can be resolved into vertical and horizontal components. The horizontal component will supply an inwards force.

Lowering the CoM means that the torque from the frictional forces acting on the tyres is smaller because the distance between the CoM and the point where the force is acting is smaller.

Example 24   2003 Q12, 30%



Points to note: Normal reaction is a contact force, so it must start at the tyre-road interface
Weight force must act from the centre of mass
Friction forces act radially inwards from the tyre-road interface
The normal reaction should be the same length as the weight force.

Example 25   1999 Question 14, 75%

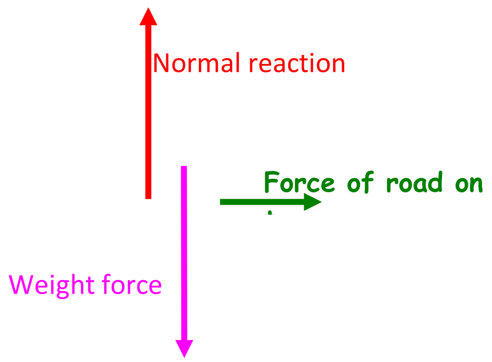
$$\Sigma F = 6400\text{ N} = \frac{mv^2}{r}$$
$$= \frac{800 \times v^2}{36.0}$$
$$v^2 = \frac{6400 \times 36}{800}$$
$$= 288$$
$$\therefore \mathbf{v = 17\ m/s} \quad \mathbf{(ANS)}$$

Example 26   1999 Question 15, 48%

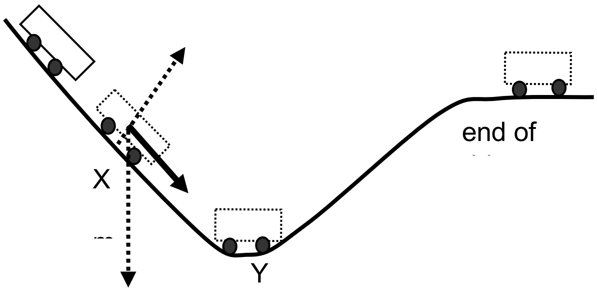
The car is moving in a circular path. For uniform circular motion there is a net force acting. This force must act horizontally, and radially inwards.

This force is given by $\Sigma F = \frac{mv^2}{r}$.

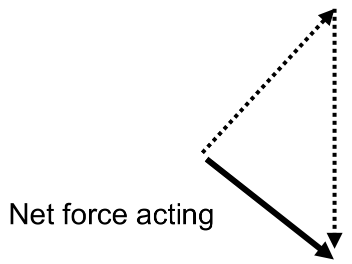
This force must be supplied by the friction between the car tyres and the road.



Example 27 1998 Question 13, 43%

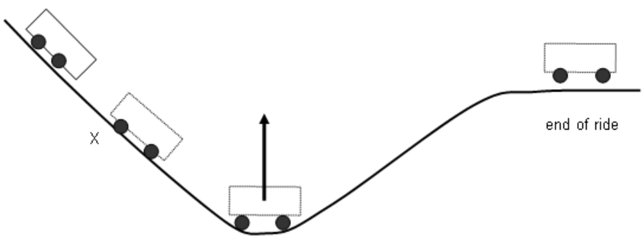


If the effects of friction are to be ignored, then the only forces acting are the weight force and the normal reaction from the track.



The cart is restricted to move in one direction, $\therefore$ the acceleration must be in this direction. We know that the cart is accelerating because it is gaining KE (by losing PE), so its speed is increasing, hence it is accelerating.
$\therefore$ the net force acting is in the direction of the acceleration, parallel to, and down the slope.

Example 28 1998 Question 14, 65%



Y

At the point Y, the cart is undergoing uniform circular motion. This means that the net force must be acting radially inwards.
$\therefore$ the net force is vertically upwards.

Example 29 1998 Question 15, 25%

The total energy must be constant.
$\therefore$ the sum of PE and KE = constant.

At X TE (total energy)

$= mgh + \frac{1}{2} mv^2$

$= 500 \times 10 \times 7.8 + \frac{1}{2} \times 500 \times 10^2$

$= 64\ 000$ J

At Y TE

$64\ 000 = \frac{1}{2} mv^2$

$= \frac{1}{2} \times 500 \times v^2$

$v^2 = \frac{63220}{250}$

$v = 16$ m s^{-1} (ANS)

Example 30 1998 Question 16, 50%

$\Sigma F = ma$

$= \frac{mv^2}{r}$

$= \frac{500 \times 15.9^2}{8.0}$

$= 1.58 \times 10^4$ N (ANS)

Example 31 1997 Question 10, 70%

$\Sigma F = ma$

$= \frac{mv^2}{r}$

$2800 = \frac{1200 \times v^2}{90}$

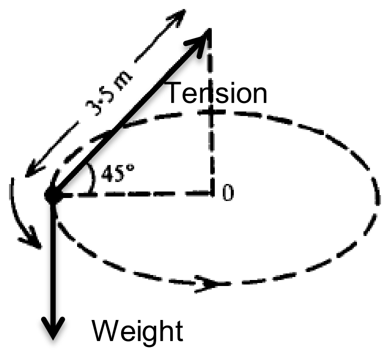
$\therefore v^2 = \frac{2800 \times 90}{1200}$

$\therefore v^2 = 210$

$\therefore v = 14.5$ m s^{-1} (ANS)

Example 32 1985 Question 25, 60%

There are two forces acting on the 0.1 kg mass, the tension in the string and the weight.



$\therefore T\sin 45^0 = mg$

$\therefore$ T = $\frac{0.1 \times 10}{\sin 45^0}$

$\therefore$ T = 1.4 N (ANS)

Example 33 1985 Question 26, 48%

The net force acting is radially inwards. Since the angle is 45^0, it will have the same magnitude as the weight. (Because the horizontal and vertical components of the tension are the same.)

$$\therefore mg = \frac{mv^2}{r}$$

To find r, use r = $3.5\cos 45^0$
= 2.47

So $\therefore 0.01 \times 10 = \frac{0.01 \times v^2}{2.47}$

$\therefore v^2 = 10 \times 2.47$

$\therefore$ v = 5.0 m s^{-1} (ANS)

Example 34 1984 Question 15, 75%

The spring constant is the gradient of the force-extension graph.

$$k = \frac{50 - 0}{1.0 - 0.5}$$

k = 100 N m^{-1} (ANS)

Example 35 1984 Question 16, 29%

The work done is the area under the force-extension graph.
When the length of the spring was 0.75 m the force was 25 N.
The area required is the area from 0.75 m to 1.0 m.
This trapezium has an area given by

WD = ½ (25 + 50) x (1.0 - 0.75)
= 9.4 J (ANS)

Example 36 1984 Question 17, 54%

When the spring is extended to 1.0 m, the force acting on it is 50 N

Using $F = \frac{mv^2}{r}$ gives

$$50 = \frac{2.0 \times v^2}{1.0}$$

$\therefore v^2 = 25$

$\therefore$ v = 5.0 m s^{-1} (ANS)

Example 37 1982 Question 8, 88%

The net force acting down is the combined weight of both masses. This is opposed by the tension in the string.

$\therefore$ T = (1.0 + 5.0) x 10

= 60 N (ANS)

Example 38 1982 Question 9, 63%

The speed is given by distance travelled over time taken. As the frequency is 2 revolutions per second the period = 0.5 sec.

$\therefore s = \frac{2\pi r}{0.5}$, where r = 2.0 m

$\therefore s = \frac{2\pi \times 2}{0.5}$

$\therefore$ **s = 25 m s^{-1} (ANS)**

Example 39 1982 Question 10, 57%

X is exerting the same force on *Y* as *Y* is exerting on *X.*

$\therefore m_y a_y = m_x a_x$

$\therefore 5a_y = 1a_x$

$\therefore \frac{\mathbf{a_y}}{\mathbf{a_x}}$ **= 0.2 (ANS)**

Example 40 1980 Question 10, 67%

There are 4 time intervals while the object travels through a quarter circle.

$\therefore$ It takes 4 x 0.125 = 0.5 sec to travel a quarter circle.

To complete the entire circle it will take 2 sec.

$\therefore$ speed = $\frac{\text{distance}}{\text{time}}$

$= \frac{2 \times \pi \times 0.20}{2}$

= 0.63 m s^{-1} (ANS)

Example 41 1980 Question 11, 78%

$a = \frac{v^2}{r}$

$\therefore a = \frac{0.6284^2}{0.2}$

$\therefore$ a = 1.97

$\therefore$ **a = 2.0 m s^{-2} (ANS)**

Example 42 1979 Question 12, 78%

(i) The table is a frictionless surface, so the only force of the table on the mass can be vertical.

$\therefore$ The normal reaction has the same magnitude as the weight.

$\therefore F_{normal} = mg$

= 0.50 x 10

= 5 N (ANS)

(ii) The direction is **UP (ANS)**

Example 43 1979 Question 14, 84%

Use $F = \frac{mv^2}{r}$

$\therefore 400 = \frac{0.5 \times v^2}{0.5}$

$\therefore v^2 = 400$

$\therefore$ **v = 20 m s^{-1}** **(ANS)**

Example 44 1972 Question 15, 78%

Sphere 2 travels twice as far as sphere 1 in the same time.

$\therefore \frac{\text{speed of sphere 2}}{\text{speed of sphere 1}} = \mathbf{2}$ **(ANS)**

Example 45 1972 Question 16, 66%

$a = \frac{v^2}{r}$

$$\therefore \frac{\text{acceleration of sphere 2}}{\text{acceleration of sphere 1}} = \frac{\frac{v_2^2}{r_2}}{\frac{v_1^2}{r_1}}$$

$$= \frac{v_2^2 r_1}{v_1^2 r_2}$$

$$= 2^2 \times \frac{1}{2}$$

$$\mathbf{= 2}$$ **(ANS)**

Example 46 1972 Question 17, 11%

The force acting is the tension in the string.
The tension between 1 and 2, acts inwardly on sphere 2 and outwardly on sphere 1.
The tension between 1 and O must have a net acting radially inward.
To get sphere 2 to accelerate, let the tension be T_2. Therefore the net tension acting on sphere 1 needs to be $\frac{1}{2}T_2$. (from Q16)
Therefore the tension between 1 and O, must be $1.5T_2$, therefore

$$\frac{\text{tension in string between spheres 1 and 2}}{\text{tension in string between spheres 1 and O}} = \frac{2}{3}$$

$\therefore$ **0.67** **(ANS)**

Non-uniform circular motion

Example 47 1985 Question 31, 64%

At the top of the track, for the normal reaction to be 'just 0', then $mg = \frac{mv^2}{r}$

$\therefore gr = v^2$

$\therefore$ **v =** $\mathbf{\sqrt{gr}}$ **(ANS)**

Example 48 1983 Question 19, 82%

$$A = \frac{v^2}{r}$$

$$= \frac{10^2}{50}$$

$\therefore$ **a = 2 m s^{-2} (ANS)**

Example 49 1983 Question 20, 47%

The net acceleration in the direction H is the vector sum of 2.0 radially inwards (westerly) and 2.0 southerly.

$\therefore$ **a = 2.8 m s^{2} (ANS)**

Question 8 (5 marks)

In an experiment, a ball of mass 2.5 kg is moving in a vertical circle at the end of a string, as shown in Figure 5.

The string has a length of 1.5 m.

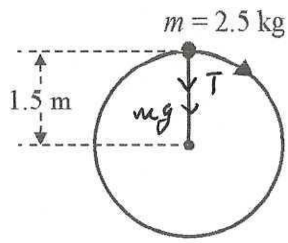


Figure 5

a. Calculate the minimum speed the ball must have at the top of its arc for the string to remain tight (under tension). 2 marks

At the top: $T + mg = \frac{mv^2}{r}$

$T = 0$

$v = \sqrt{gr}$

3.9 m s^{-1}

b. In another experiment, the ball is moving at 6.0 m s^{-1} at the top of its arc.

Calculate the speed of the ball at the lowest point. 3 marks

$\frac{m \times 6^2}{2} + mg \times 1.5 = \frac{mv^2}{2}$

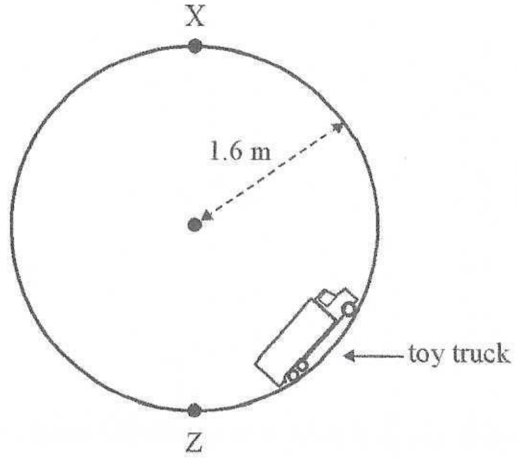
$v = \sqrt{m \times 6^2 + 2 \times 1.5 \times g}$

$= 9.8$

9.8 m s^{-1}

Use the following information to answer Questions 8 and 9.

A toy truck travels on a track around a vertical loop of radius 1.6 m, as shown below. Assume that the toy truck is a point mass.



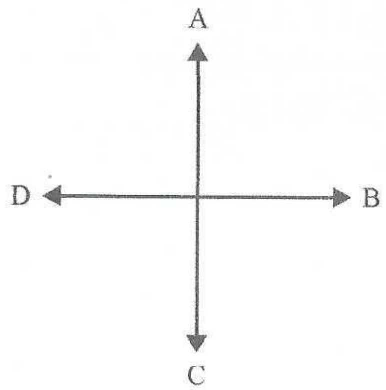
Question 8

The minimum speed at which the toy truck must be moving at point X for it to stay on the track is closest to

A. 1.6 m s^{-1}
B. 3.2 m s^{-1}
C. 4.0 m s^{-1}
D. 16 m s^{-1}

$v = \sqrt{gr}$

Question 9



Which direction best shows the direction of the resultant force on the toy truck at point Z?

A. A
B. B
C. C
D. D

Centripetal force towards the center

Question 8 (9 marks)

A 250 g toy car performs a loop in the apparatus shown in Figure 8.

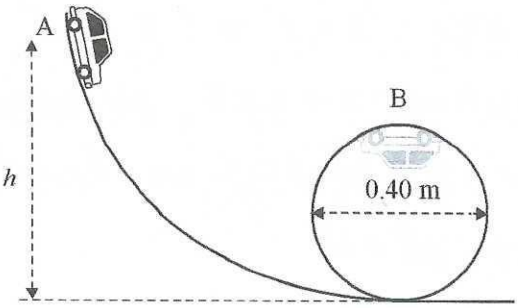


Figure 8

The car starts from rest at point A and travels along the track without any air resistance or retarding frictional forces. The radius of the car's path in the loop is 0.20 m. When the car reaches point B it is travelling at a speed of 3.0 m s^{-1}.

a. Calculate the value of h. Show your working. 3 marks

$mgh = \frac{mv^2}{2} + mg \times 0.4$

$h = \frac{v^2}{2g} + 0.4$

$= \frac{3^2}{2 \times 9.8} + 0.4$

$= 0.86$

0.86 m

b. Calculate the magnitude of the normal reaction force on the car by the track when it is at point B. Show your working. 3 marks

$N + mg = \frac{mv^2}{r}$ $N = \frac{mv^2}{r} - mg = \frac{0.25 \times 3^2}{0.2} - 0.25 \times 9.8$

$= 8.8$

8.8 N

c. Explain why the car does not fall from the track at point B, when it is upside down. 3 marks

$N > 0$

Min speed $v = \sqrt{gr} = 1.4$ $3 ms^{-1} > 1.4 ms^{-1}$ (2 m)

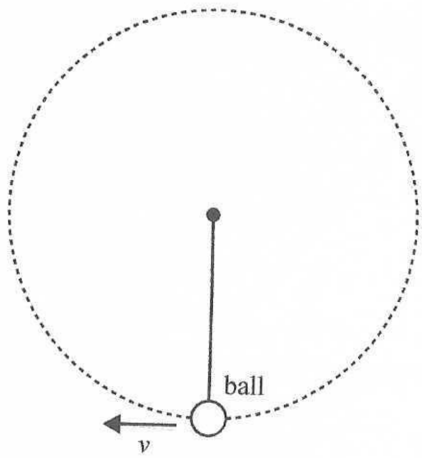
As $N > 0$ track pushing on car, so according to 3rd Newtons Law car pushing on track

$\frac{mv^2}{r} > mg$ so $N > 0$

$a = \frac{v^2}{r} = \frac{3^2}{0.2} = 45 ms^{-2} > g$ (2 m)

Question 8 56 %

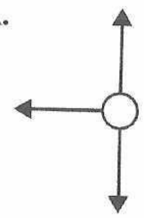
A ball is attached to the end of a string and rotated in a circle at a constant speed in a vertical plane, as shown in the diagram below.



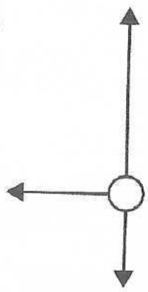
The arrows in options A. to D. below indicate the direction and the size of the forces acting on the ball.

Ignoring air resistance, which one of the following best represents the forces acting on the ball when it is at the bottom of the circular path and moving to the left?

A.



B.



C.

D.

There are only gravity and tension acting. Tension is greater than gravity as acceleration is up towards the center.

Question 8 (6 marks)

Figure 8 shows a small ball of mass 1.8 kg travelling in a horizontal circular path at a constant speed while suspended from the ceiling by a 0.75 m long string.

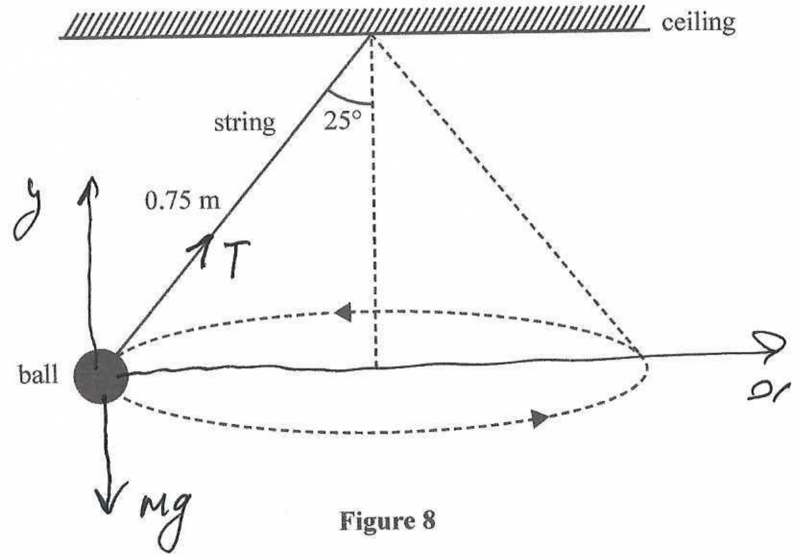


Figure 8

54 %

a. Use labelled arrows to indicate on Figure 8 the two physical forces acting on the ball. 2 marks

b. Calculate the speed of the ball. Show your working. 4 marks

39 %

$x: \; T\sin(25°) = \frac{mv^2}{r} \qquad r = 0.75\sin(25°) = 0.32$

$y: \; T\cos(25°) = mg \qquad T = \frac{mg}{\cos 25°} = \frac{1.8 \times 9.8}{\cos 25°} = 19.46\ N$

$v = \sqrt{\frac{rT\sin(25°)}{m}} = \sqrt{\frac{0.32 \times 19.46 \sin(25°)}{1.8}}$

$= 1.2\ ms^{-1}$

1.2 m s^{-1}

Question 9 (10 marks)

Abbie and Brian are about to go on their first loop-the-loop roller-coaster ride. As competent Physics students, they are working out if they will have enough speed at the top of the loop to remain in contact with the track while they are upside down at point C, shown in Figure 9. The radius of the loop CB is r.

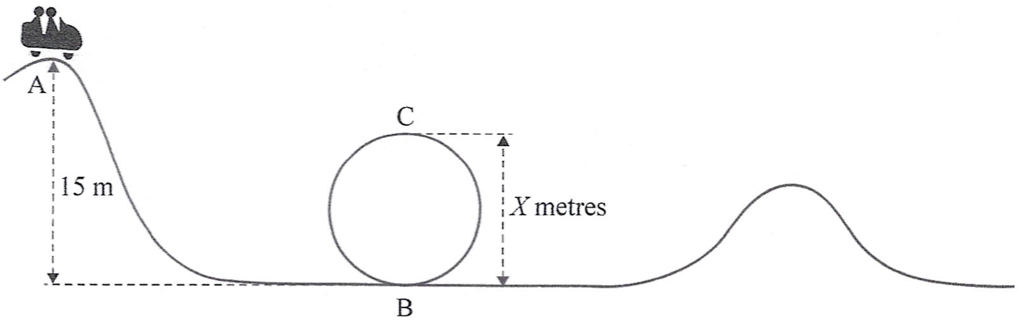


Figure 9

The highest point of the roller-coaster (point A) is 15 m above point B and the car starts at rest from point A. Assume that there is negligible friction between the car and the track.

a. What is the speed of the car at point B at the bottom of the loop? Show your working. 2 marks

53%

$mg \times 15 = \frac{mv^2}{2}$

$v = \sqrt{2 \times 9.8 \times 15}$

17.1 m s^{-1}

b. By considering the forces acting on the car, show that the condition for the car to just remain in contact with the track at point C is given by $\frac{v^2}{r} = g$. Show your working. 2 marks

49%

$\frac{\cancel{m}v^2}{r} = \cancel{m}g$

$\frac{v^2}{r} = g$

c. What is the maximum height of the loop (X metres) that will ensure that the car stays in contact with the track at point C? Show your working.

3 marks

11%

$mg(15 - x) = \frac{mv^2}{2}$

$v^2 = gr = g \times \frac{x}{2}$

$2g(15 - x) = \frac{gx}{2}$

$4(15 - x) = x$

$60 = 5x$

12 m

d. If friction is taken into account, will Abbie and Brian need to increase or decrease their predicted value for the radius of the loop? Explain your answer.

3 marks

27%

Speed decreases. So radius needs to be decreased as $r = \frac{v^2}{g}$

Question 7 (7 marks)

A spherical mass of 2.0 kg is attached to a piece of string with a length of 2.0 m. The spherical mass is pulled back until it makes an angle of 60° with the vertical, as shown in Figure 4. The spherical mass is then released. Ignore the mass of the string.

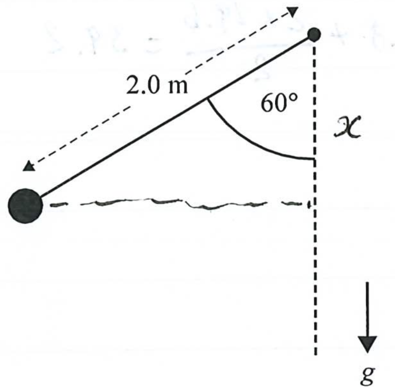


Figure 4

a. Show that the maximum speed of the spherical mass is 4.4 m s^{-1}. 2 marks

$x = 2\cos 60° = 1\,m$

$h = 2 - 1 = 1\,m$

$mgh = \frac{mv^2}{2}$

$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 1} = 4.4\,m\,s^{-1}$

b. At what part of its path is the spherical mass at its maximum speed? Explain your reasoning. 2 marks

Maximum v is at the lowest point as gravitational potential energy is minimum and so kinetic en. is max. as total en. remains const.

DO NOT WRITE IN THIS AREA

c. Calculate the maximum tension in the string. 3 marks

$T - mg = \frac{mv^2}{r}$

$T = mg + \frac{mv^2}{r} = 2 \times 9.8 + \frac{2 \times 19.6}{2} = 39.2$

39.2 N

Question 9 (5 marks)

A small ball of mass 0.30 kg travels horizontally at a speed of 6 m s^{-1}. It enters a vertical circular loop of diameter 0.80 m, as shown in Figure 6. Assume that the radius of the ball and that the frictional forces are negligible.

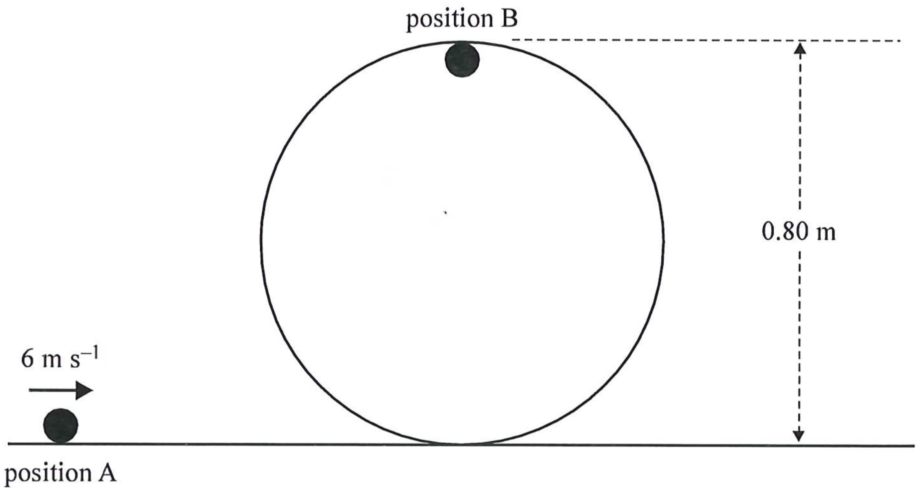


Figure 6

a. Show that the kinetic energy of the ball at position A in Figure 6 is 5.4 J. 1 mark

$\frac{mv^2}{2} = \frac{0.3 \times 6^2}{2} = 5.4$

b. Will the ball remain on the track at the top of the loop (position B in Figure 6)? Give your reasoning. 4 marks

$mg \times 0.8 + \frac{mv^2}{2} = 5.4$

$0.3 \times 9.8 \times 0.8 + 0.15v^2 = 5.4$

$0.15v^2 = 3.048$ $v = 4.5\ ms^{-1}$

Minimum speed required $\sqrt{gr} = \sqrt{9.8 \times 0.4} = 1.98$

$4.5 > 2.8$, yes, will remain on track

or

$N = \frac{mv^2}{R} - mg = \frac{0.3 \times 4.5^2}{0.4} - 0.3 \times 9.8 = 12.2\ N > 0$

Question 8 (5 marks)

A Formula 1 racing car is travelling at a constant speed of 144 km h^{-1} (40 m s^{-1}) around a horizontal corner of radius 80.0 m. The combined mass of the driver and the car is 800 kg. Figure 8a shows a front view and Figure 8b shows a top view.

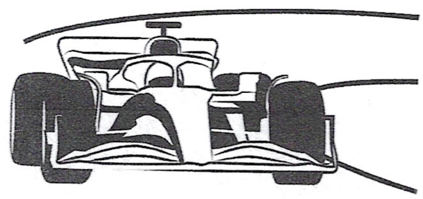


Figure 8a – Front view

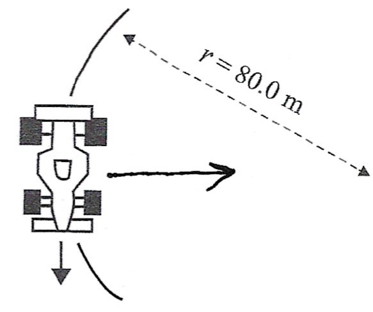


Figure 8b – Top view

a. Calculate the magnitude of the net force acting on the racing car and driver as they go around the corner. 2 marks

$F = \frac{mv^2}{r} = \frac{800 \times 40^2}{80}$

78%

16000 N

b. On Figure 8b, draw the direction of the net force acting on the racing car using an arrow. 1 mark

See ~~F~~ Figure 8b

84%

c. Explain why the racing car needs a net horizontal force to travel around the corner and state what exerts this horizontal force. 2 marks

Force needed to change direction to maintain circular motion.

This is frictional force on tyres from the road

21%

Question 11 (9 marks)

Lee ties a small ball of mass 100 g to a string and rotates it in a vertical circle, as shown in Figure 11a. Assume that the ball is rotated at a constant speed of 3.0 m s^{-1}. The radius, r, of the circle is 0.60 m. Figure 11b shows a side view.

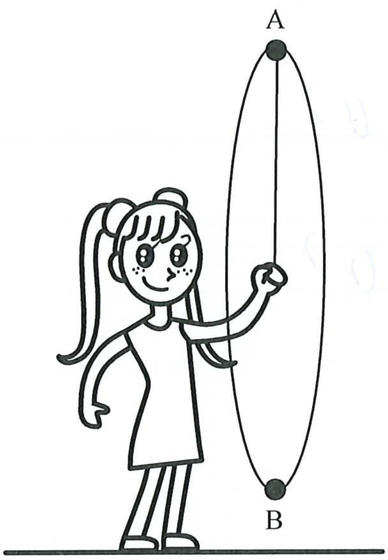


Figure 11a

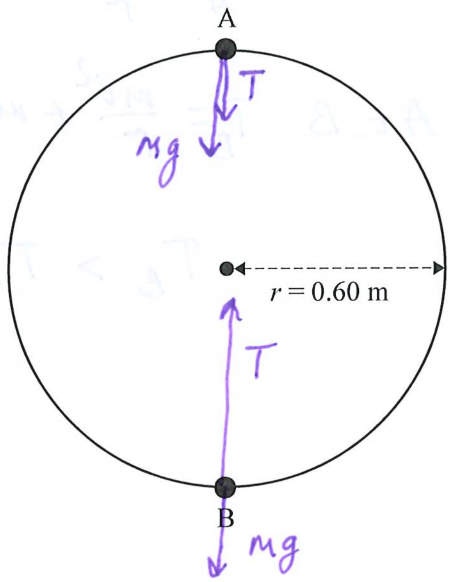


Figure 11b

a. On Figure 11b, draw arrows to represent each of the forces acting on the small ball at position A, at the top of the circle, and at position B, at the bottom of the circle. Label each arrow clearly and use the lengths of the arrows to show the relative approximate magnitudes of the forces. No calculations are required. 4 marks

b. Calculate the tension force in the string when the ball is at position B. Use $g = 10$ m s^{-2}. 2 marks

$T - Mg = \frac{MV^2}{r}$

$T = Mg + \frac{mV^2}{r} = 0.1 \times 10 + \frac{0.1 \times 3^2}{0.6}$ (1)

$= 2.5$ (1)

2.5 N

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c. Lee now increases the speed of the ball to a new constant speed, which is greater than 3.0 m s^{-1}, and notices that the string breaks when the ball is at position B.

Explain why the string is more likely to break at position B than at position A. 3 marks

At A $T_A = \frac{mv^2}{r} - mg$ (1)

At B $T_B = \frac{mv^2}{r} + mg$ (1)

$T_B > T_A$ (1)

DO NOT WRITE IN THIS AREA

b. Giorgos swings his racquet from point D through point C, which is horizontally behind him at shoulder height, as shown in Figure 11, to point B. Eka models this swing as circular motion of the racquet head. The centre of the racquet head moves with constant speed in a circular arc of radius 1.8 m from point C to point B.

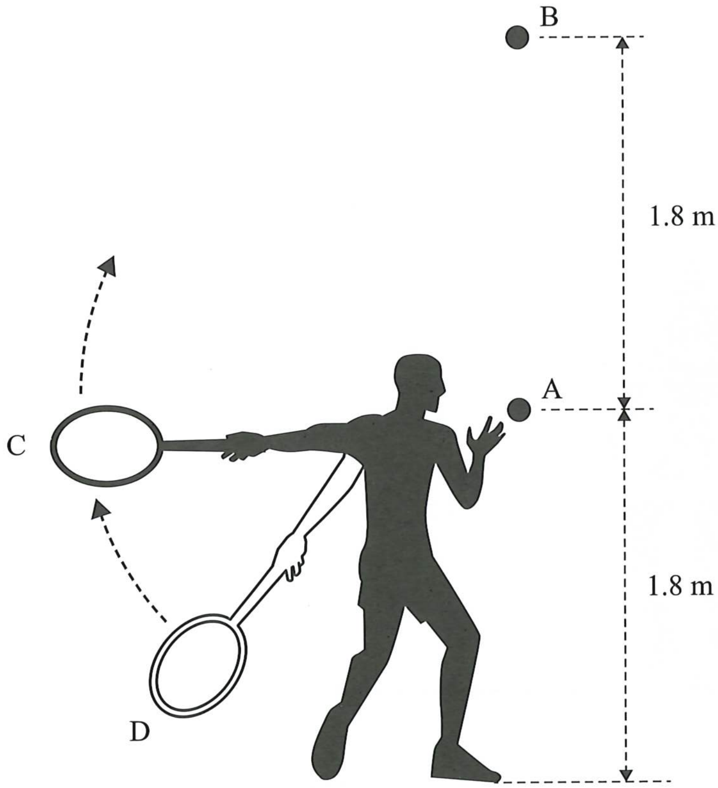

Figure 11

The racquet passes point C at the same time that the ball is released at point A and then the racquet hits the ball at point B.

Calculate the speed of the racquet at point C. 2 marks

$T = \frac{2\pi r}{4v}$ $v = \frac{2\pi r}{4T} = \frac{2\pi \times 1.8}{4 \times 0.6} =$ 4.7

4.7 m s^{-1}