Problem solving with circular motion (A2)

Starter

1. **(Review of last lesson)** A bead of mass m kg is threaded on a smooth circular wire, of radius 2 m, fixed in a vertical plane. Starting from the highest position the bead has an initial speed of 4 m/s. Point P is when the bead is $30°$ short of reaching the downward vertical. Find as it passes through P:
   (a) the speed of the bead
   (b) the radial acceleration
   (c) the tangential acceleration.

Notes

The velocity of a particle can be so great that it leaves the circle e.g. string snapping.

Particle on the end of a string

The particle will continue to move round in a circle so long as tension is greater than or equal to zero and the tension is not so great as to snap the string.

Particle moving on the inside or outside of a spherical surface

The normal contact force acts along the radius.

- ***Inside*** the sphere — directed ***towards the centre.***
- ***Outside*** the sphere — directed ***away from the centre.***

The particle remains in contact with the surface until the normal contact force, R, is zero. At this point the particle becomes a projectile.

E.g. 1 A particle P, of mass m kg, moves round a vertical circle of radius 0.5 m with an angular speed of 4 rad/s. Determine whether P is still moving around in a circle $60°$ after the highest point if P is sliding:
(a) on the inside
(b) on the outside of a smooth surface.

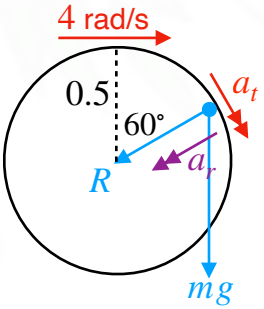
Working: (a) The normal force, R, acts towards the centre.

$a_r = r\omega^2 = 0.5 \times 4^2 = 8$

$F = ma$ radially: $R + mg\cos 60 = ma_r$

$R \approx 3.1m$

Since $m > 0$, $R > 0$, the particle P is still in contact with the surface.



Some questions require the use of the ***principle of conservation of energy***.

E.g. 2 A bead P, of mass 1 kg, is threaded on a smooth circular wire, of radius 0.2 m, that is fixed in a vertical plane. P is projected from the lowest point at 2.5 m/s. Find the angle through which OP has rotated when the reaction between the wire and the bead is zero.

Some questions require the use of ***projectiles***.

E.g. 3 The roof of an arena is a dome in the shape of a hemisphere of radius 30 m. A lump of ice at the top of the dome starts to slide down the surface. Calculate the distance from the base of the dome where the block of ice will hit the ground?

Video: Circular motion
Video: Motion in a vertical circle (sphere)
Video: Circular motion (vertical example)

Solutions to Starter and E.g.s

Exercise
p248 9C Qu 1-9

Summary
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