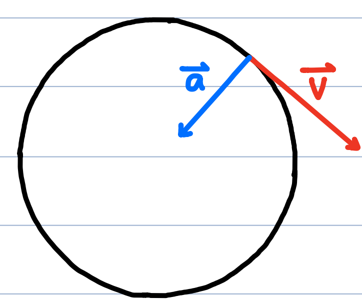
CIRCULAR MOTION

CENTRIPETAL ACCELERATION

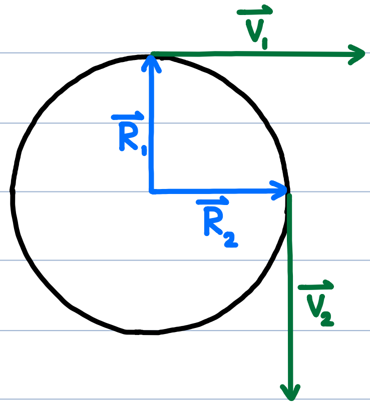
- AN OBJECT MOVING AT A CONSTANT SPEED IN A CIRCLE EXPERIENCES CENTRIPETAL ACCELERATION.

	SPEED	DIRECTION
LINEAR ACCELERATION	CHANGING	CONSTANT
CENTRIPETAL ACCELERATION	CONSTANT	CHANGING

- THE VELOCITY AT ANY INSTANT IS TANGENT TO THE CIRCLE.
- FORCE AND ACCELERATION ARE PERPENDICULAR TO THE VELOCITY, DIRECTED INWARD TOWARDS THE CENTRE OF THE CIRCLE

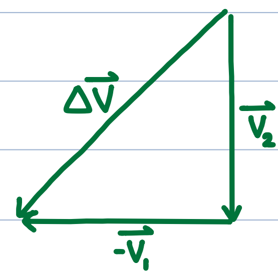


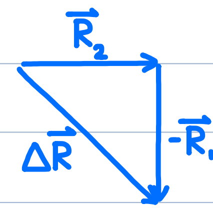
DERIVING CENTRIPETAL ACCELERATION



$$\vec{a} = \frac{\Delta\vec{V}}{t}$$

$$\Delta\vec{V} = \vec{V}_2 - \vec{V}_1 \qquad \Delta\vec{R} = \vec{R}_2 - \vec{R}_1$$





$$V_1 = V_2 = V \qquad R_1 = R_2 = R$$

SIMILAR TRIANGLES

$$\frac{\Delta V}{\Delta R} = \frac{V}{R}$$

$$\Delta V = \frac{V\Delta R}{R}$$

$= v$

$$\vec{a} = \frac{\Delta\vec{V}}{t} = \frac{V}{R}\left(\frac{\Delta R}{t}\right) \qquad v = \frac{d}{t}$$

$$= \frac{2\pi R}{T}$$

$$a_c = \frac{V^2}{R} \qquad V^2 = \frac{4\pi^2 R^2}{T^2}$$

$$= \frac{4\pi^2 R}{T^2}$$

$$\boxed{a_c = \frac{V^2}{R} = \frac{4\pi^2 R}{T^2}}$$

a_c: CENTRIPETAL ACCELERATION ($\frac{m}{s^2}$)
V: TANGENTIAL VELOCITY ($\frac{m}{s}$)
R: RADIUS OF CURVATURE (m)
T: PERIOD (s)

- IF THE NET FORCE ON AN OBJECT CAUSES UNIFORM CIRCULAR MOTION, WE CALL THIS NET FORCE THE CENTRIPETAL FORCE.

$$\boxed{F_c = ma_c}$$

F_c: CENTRIPETAL FORCE (N)
m: MASS (kg)
a_c: CENTRIPETAL ACCELERATION ($\frac{m}{s^2}$)

EXAMPLE

A CAR IS TRAVELLING AT 10 $\frac{m}{s}$ (36 $\frac{km}{h}$) AND MAKES SEVERAL TURNS. CALCULATE THE CENTRIPETAL ACCELERATION FOR...

a) A CURVE OF RADIUS 50 m (HIGHWAY EXIT).

b) A CURVE OF RADIUS 10 m (PARKING LOT).

c) A CURVE OF RADIUS 4 m (CITY STREET).

EXAMPLE

A CAR IS TRAVELLING AROUND A CIRCULAR TRACK OF RADIUS 80 m. THE COEFFICIENT OF FRICTION IS 0.80 IN DRY WEATHER. FRICTION PROVIDES INWARD F_c

a) DETERMINE THE MAXIMUM TRACK SPEED.

① DRAW A FREE-BODY DIAGRAM.

② WRITE DOWN NEWTON'S SECOND LAW ($F_c = ma_c$).

③ REPLACE F_c WITH THE VECTOR SUM OF ALL FORCES.

CONSIDER INWARDS TO BE THE POSITIVE DIRECTION.

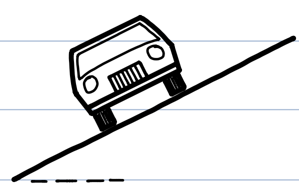
b) WHAT IS THE LAP TIME AT THIS SPEED?

c) IF THE TRACK IS WET, THE COEFFICIENT OF FRICTION IS 0.50. DOES THE MAXIMUM VELOCITY INCREASE, DECREASE OR STAY THE SAME?

EXAMPLE

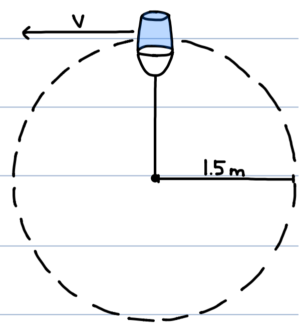
CIVIL ENGINEERS DESIGN EXIT RAMPS AND CURVES TO ASSIST DRIVERS. CONSIDER A CAR TRAVELLING AT 60 $\frac{km}{h}$ AROUND A 50 m RADIUS CURVE. WHAT ANGLE SHOULD THE ROADBED HAVE TO ACCOMODATE THIS TURN?

BY BANKING (TILTING) THE ROADBED, THE NORMAL FORCE PROVIDES THE INWARD F_c.



EXAMPLE

A 4.0 kg BUCKET OF WATER IS SWUNG IN A VERTICAL CIRCLE OF RADIUS 1.5 m. IF THE PERIOD OF REVOLUTION IS 0.75 s, WHAT IS THE TENSION IN THE ROPE AT



a) THE BOTTOM OF THE CIRCLE?

b) THE TOP OF THE CIRCLE?

c) WHAT IS THE MINIMUM SPEED AT THE TOP OF THE CIRCLE IF THE WATER DOES NOT SPILL FROM THE BUCKET?

MINIMUM SPEED OCCURS WHEN F_c IS AT A MINIMUM. THIS IS THE CASE IF TENSION IS ZERO.