Toppersnotes
Unleash the topper in you

DRDO-MTS

DEFENCE RESEARCH &
DEVELOPMENT ORGANISATION

GENERAL SCIENCE

SIERRA
INNOVATIONS

General Science

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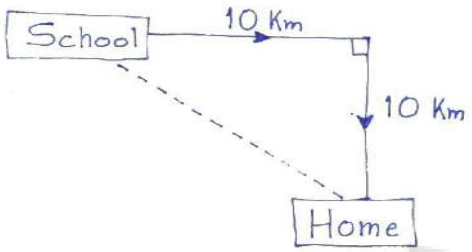
PHYSICS

Motion

(i) Distance (x)

(ii) Displacement (s)

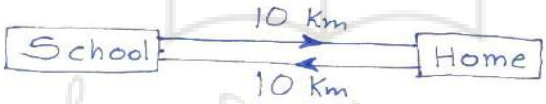
Case-I



$x = 20$ Km

$s = 10\sqrt{2}$ Km

Case-II



$x = 10 + 10 = 20$ Km

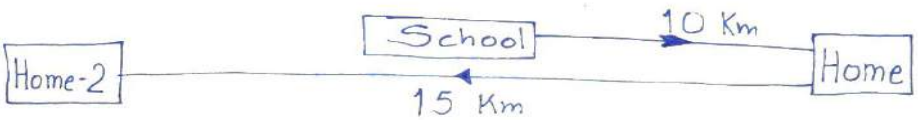
$s = (+10) + (-10) = 0$ Km

Assuming left side to be (−ve)

Assuming right side to be (+ve)

This assumption is known as 'Frame of Reference'.

Case-III



$x = 10 + 15 = 25$ Km

$s = (+10) + (-15) = -5$ Km

Vectors: Quantities which represent opposite direction if signs get changed from +ve to −ve.

Scalars: Usually, what is not a vector is a scalar.
'Frame of Reference' is valuable only for vectors.

(iii) **Speed**  (The value on speedometer)

(iv) **Velocity** =  + Direction

Speed — Scalar

Velocity — Vector

Direction of velocity is tangential to the motion.

(v) **Acceleration** = Rate of change in velocity

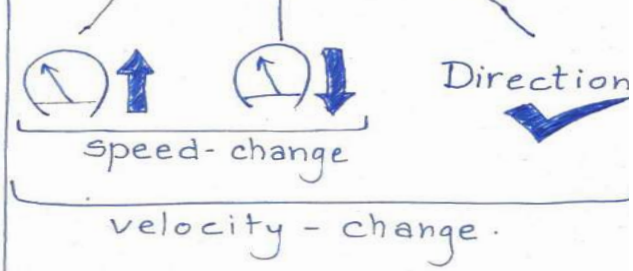
Jeep 0 Kmph to 60 Kmph in 15s

Ferrari 0 Kmph to 60 kmph in 3s

Change is velocity is same but rate is different

- In layman terms, acceleration is 'pickup' of a vehicle.

by 3 ways

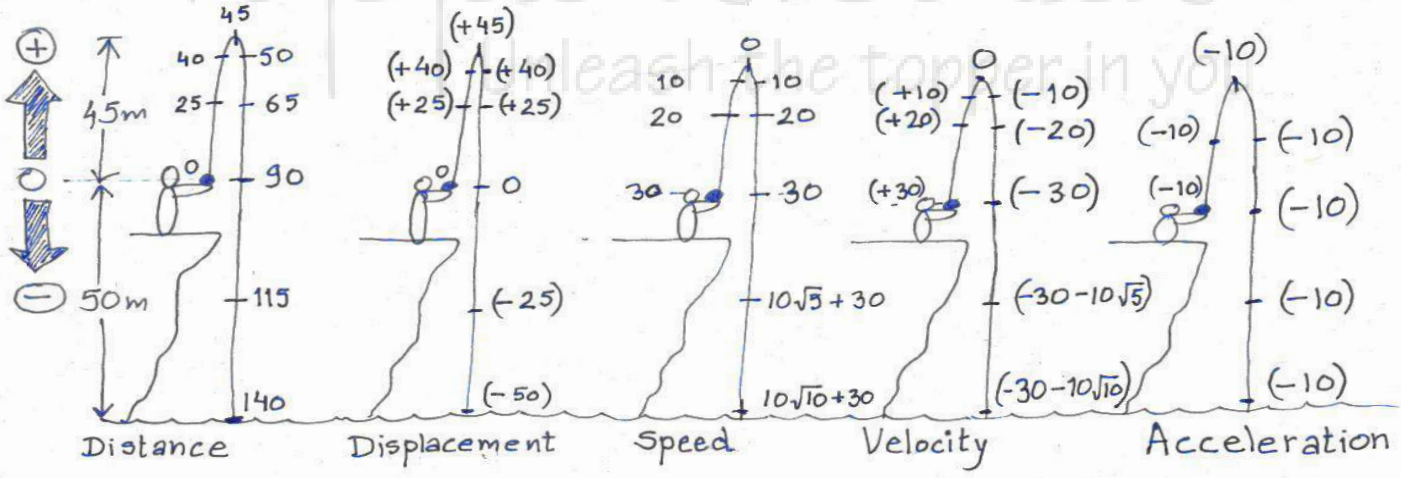


★ Direction of displacement tells, which side the object is.

★ Direction of velocity tells, which side the object is going.

★ Direction of acceleration tells, which side the object is experiencing a force.

The direction of acceleration is always towards the applied force.



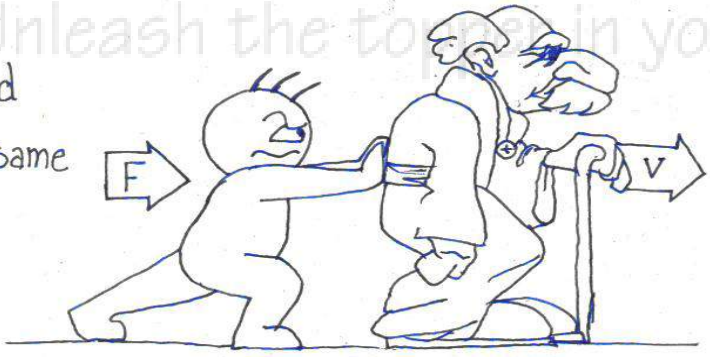
Distance is the value on odometer.
while speed is the value on speedometer.

The grand table

Case	Angle		Direction
v, F	0°	↑	✗
v, F	180°	↓	✗
v, F	90°	✗	✓

Case 1:

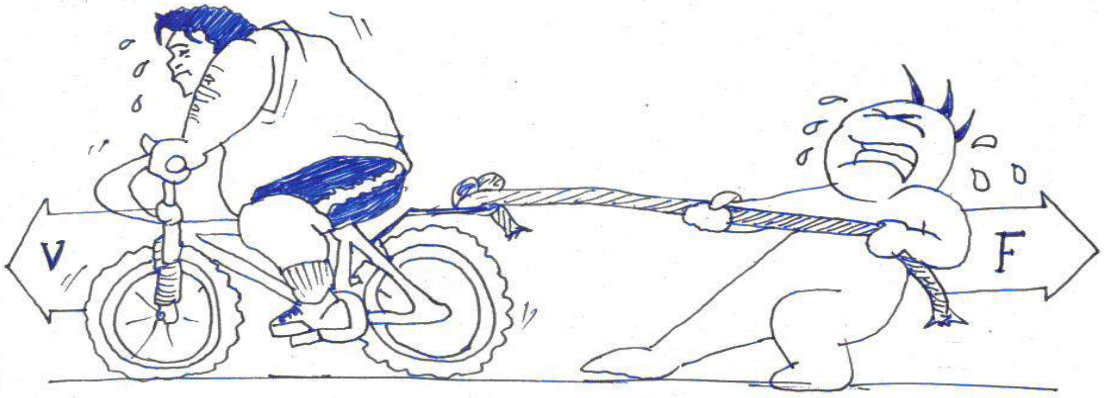
When 'velocity' and 'Force' are in the same direction



Important note: If a body moving in $+x$ direction starts going in $-x$ direction later, mathematically it is not referred as a direction change as the body is still on the same axis.

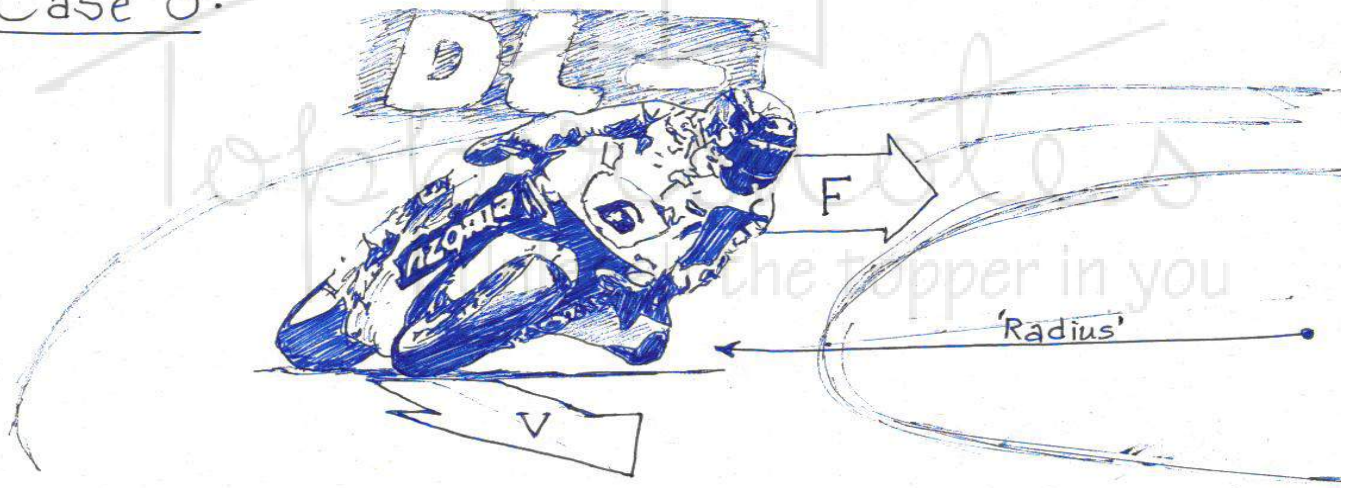
Direction changes if axis changes, like 'x' to 'y' or 'z'.

Case 2:



When 'velocity' and 'Force' are opposite.

Case 3:

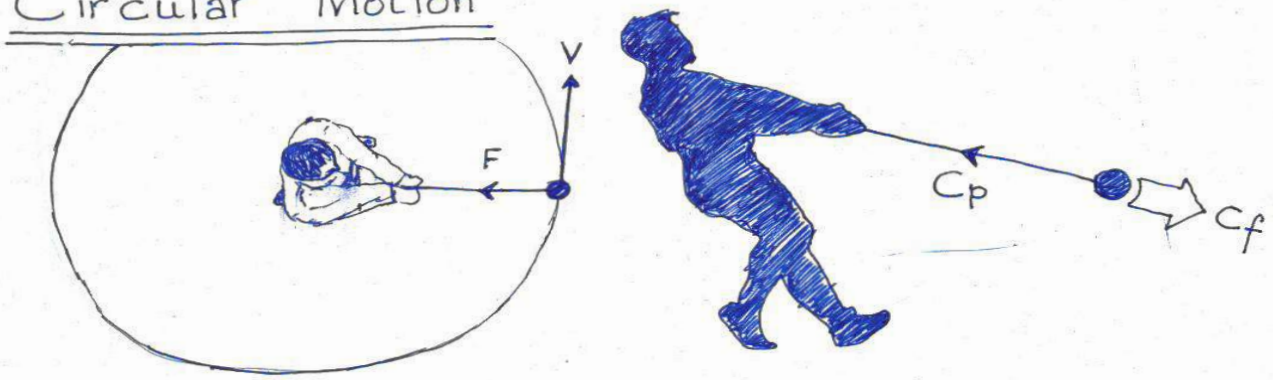


Force (inwards the radius) is perpendicular to velocity (tangential to the curvature)

Forces may be of many types. Various forms of force depicted in these examples are:

Case 1 : Contact force (Normal reaction)
Case 2 : Tension force of string
Case 3 : Contact force (Friction)

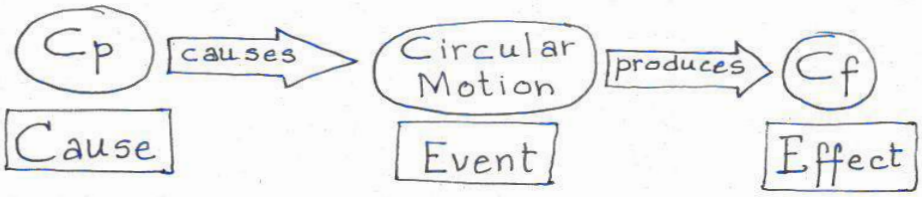
Circular Motion

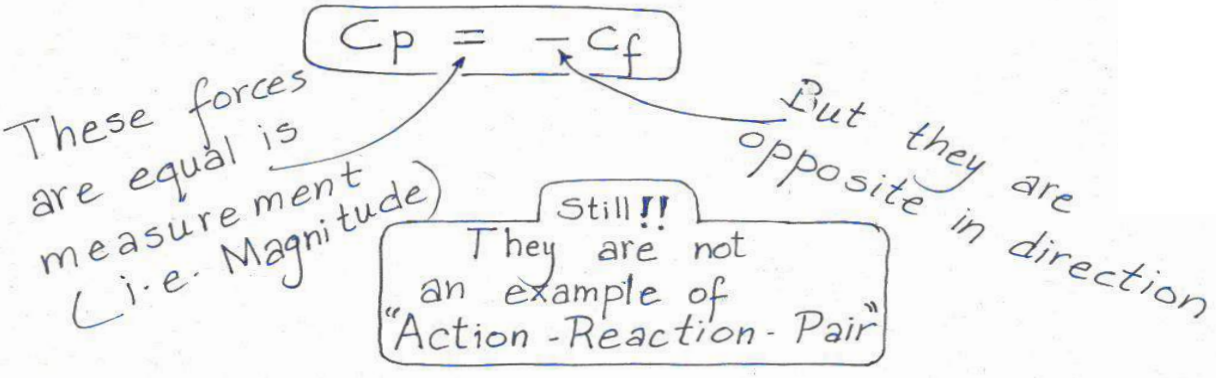


Centripetal force : Towards the center
: Responsible for circular motion
: Perpendicular to velocity

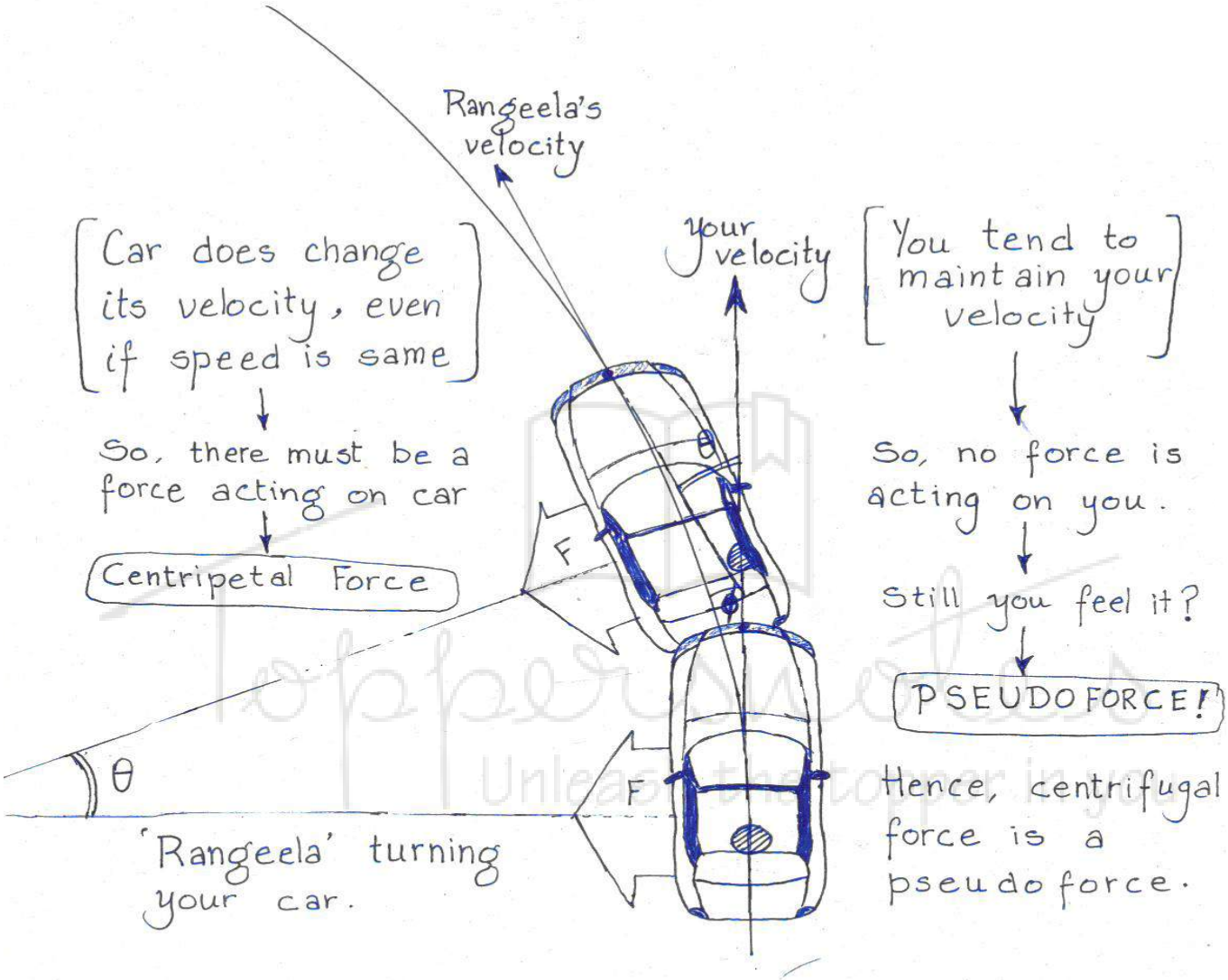
As there is this force (Cp now onwards), so there is acceleration. Hence, every circular motion is an accelerated motion.

Centrifugal force : Away from center
: Effect of circular motion
: Perpendicular to velocity

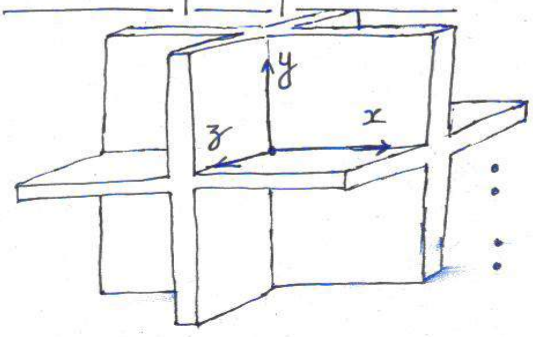




Origin of Centrifugal force



Frame of reference : The arbitrarily chosen origin & the axes in spce, from where measurement is done

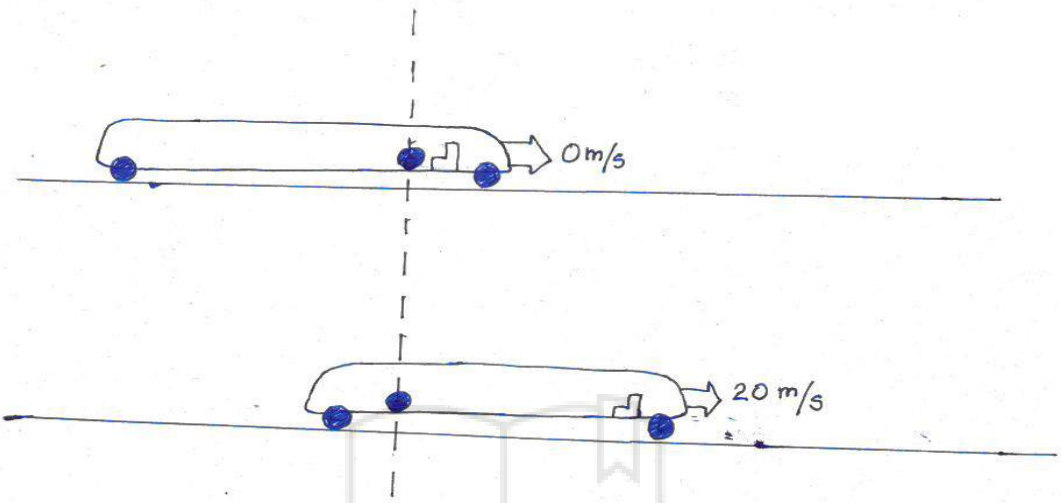


: Useful only in vectors

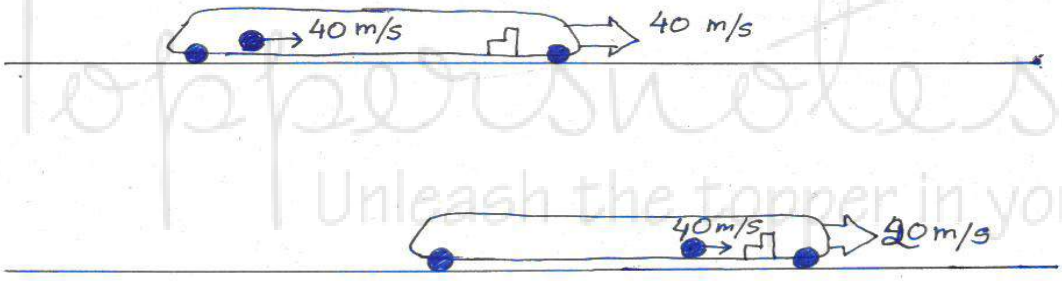
: In short, it is a man observing motion with (i) a meter rod & (ii) a stop watch.

Pseudoforces are of 3 types

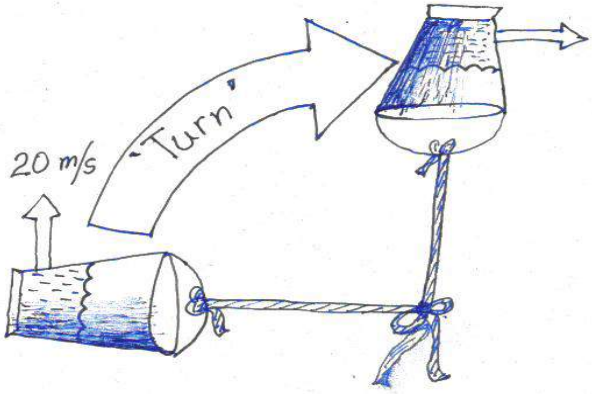
(i) Due to increasing speed of environment



(ii) Due to decrease in speed of environment



(iii) Due to change in direction of motion of environment



Pseudoforces form the basis of 'Inertia'.

Newton's laws of Motion

(i) **Inertia**

- **of Rest** (Marble ball in 'accelerating' metro)

- **of Motion** (Marble ball in decreasing speed)

- **of Direction** ('Rangeela' turning your car)

Condition to check the law of Inertia (or the law of conservation of linear momentum) is that <u>external force</u> must be zero.

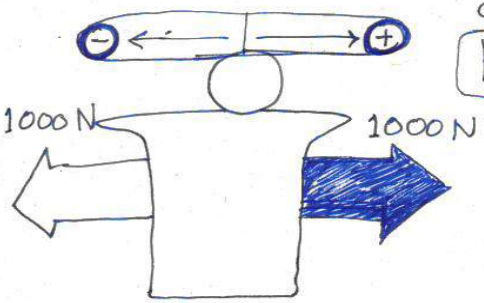
(ii) $F = ma$

F = force → if $F = k_1$, $m \propto 1/a$

m = mass → if $m = k_2$, $F \propto a$

a = acceleration → if $a = k_3$, $F \propto m$

k = constant



$F \neq 2000\,N$

$F = (+1000\,N) + (-1000\,N)$

$= 0\,N$

Hence force is a vector quantity.

$F = m\,a$

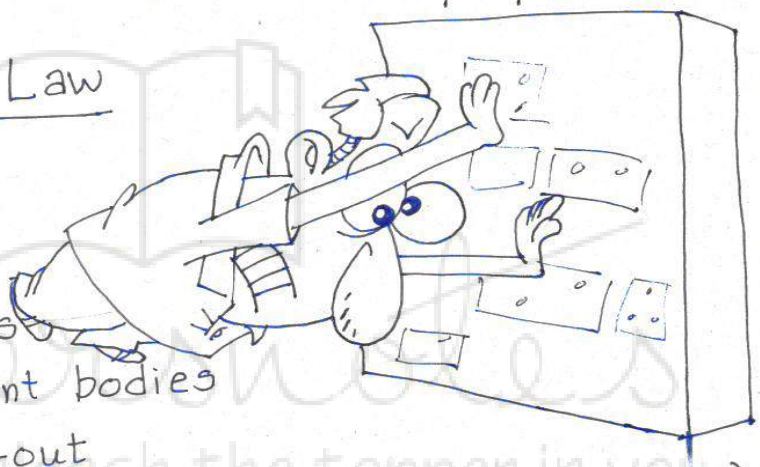
$-90 + 40 = 10 \cdot a$

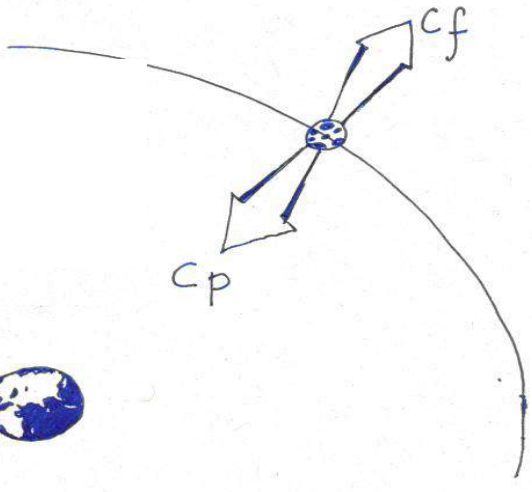
$-50 = 10\,a$

$a = -5$ Hence direction of acceleration is same as that of force.

(iii) Action-Reaction Law

(i) Equal
(ii) Opposite
(iii) Simultaneous
(iv) Act of different bodies
(v) Never cancel-out
(vi) Act on same surface (if contact forces)





Moon rotating around earth

(i) $C_p = C_f$ in magnitude

(ii) C_p is opposite to C_f

Still C_p & C_f do not make action-reaction pair because both C_p & C_f act on same body i.e. the Moon.

$m_1 = 3 \times 10^{-1}$ Kg

$a_1 = 10$ m/s^2

$F_1 = m_1 a_1 = 3$ N

$\vec{F_1} = -\vec{F_2}$

$F_2 = 3$N

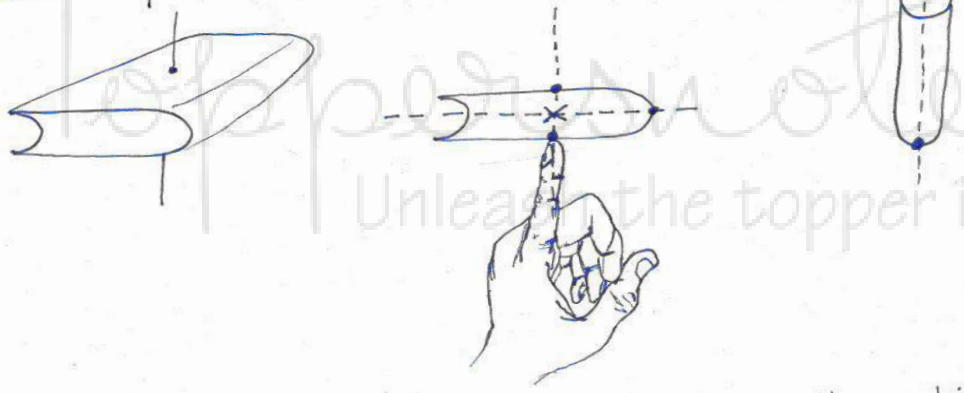
$m_2 = 6 \times 10^{24}$ Kg

$a_2 = 5 \times 10^{-25}$ m/s^2

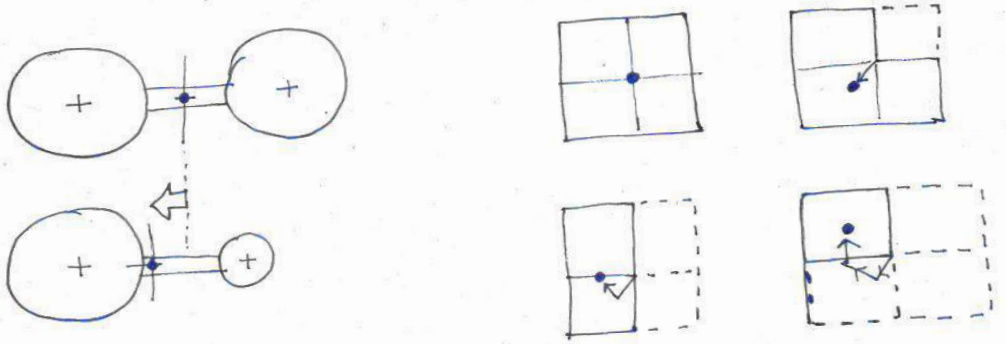
$\therefore a_2 = 0.\underbrace{000000000000000000000000}_{24 \text{ zeroes}}5$ m/s^2

Hence, earth also bounces upwards as apple falls. But acceleration is too low to make it observable.

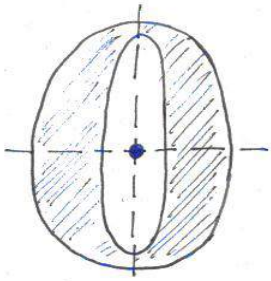
Centre of mass (c.m.)



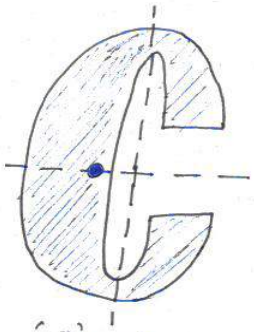
c.m. shifts towards heavy part of the object



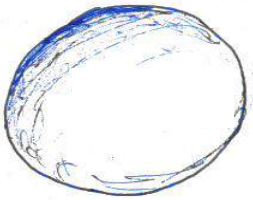
It is not necessary that material is also present at centre of mass.



Symbol of opera mini



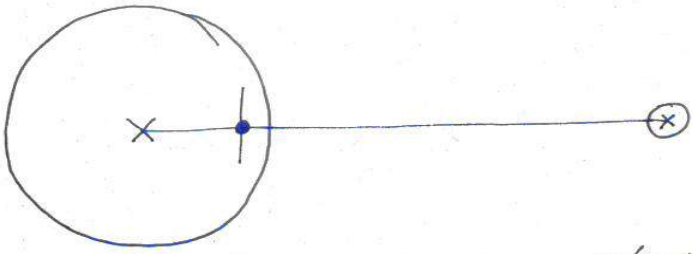
'C'- shape



A 'T-T' ball
(no plastic is present at c.m.)

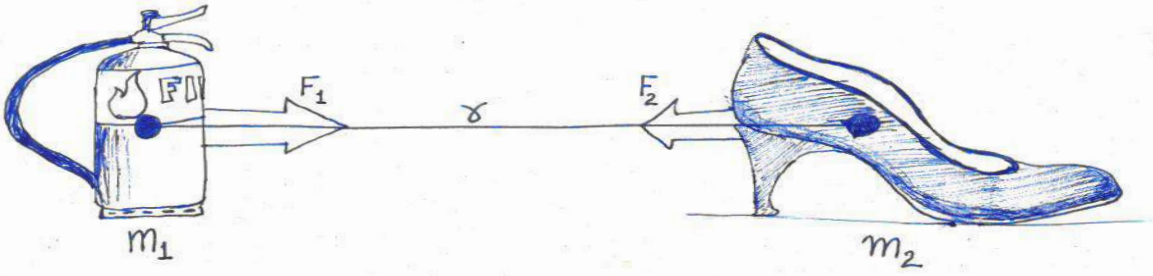
Concept of planets and satellites

Binary planets



Planet - satellite system

Gravitation



Any two objects attract each other due to mass in them with forces F_1 & F_2 & $\boxed{F_1 = F_2}$ always.

★ 'r' is the centre to centre gap between objects

★ 'm_1' & 'm_2' are respective masses of objects.

Thus, $F_1 = F_2 = \boxed{F = \frac{G m_1 m_2}{r^2}}$

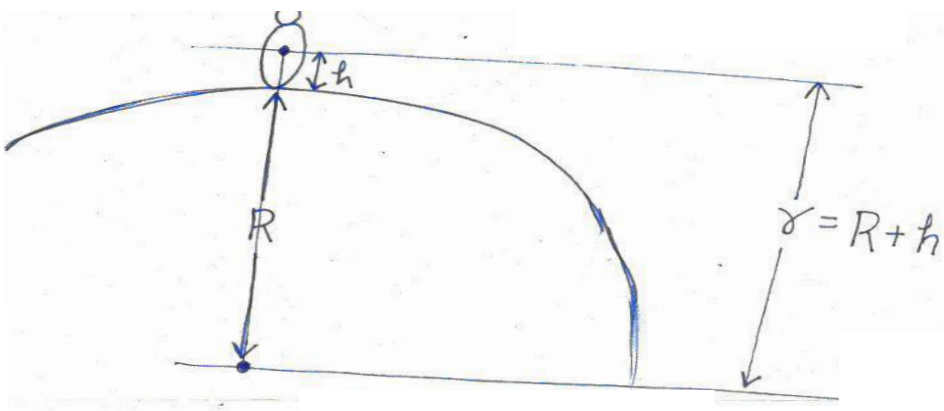
$F_1 = m_1 a_1$

$F_2 = m_2 a_2$

★ 'G' is known as gravitational constant.

$G = 6.67 \times 10^{-11}\ Nm^2/Kg^2$

Acceleration due to gravity



$F = \frac{G m_1 m_2}{r^2}$

$m_1 a_1 = \frac{G m_1 m_2}{r^2}$

$\boxed{a_1 = \frac{G m_2}{r^2}}$

Thus, a_1 is independent of mass of object, m_1.
That's why, two objects released
- from same height
- in vacuum
- simultaneously

reach earth together

- even if mass is different

So, it doesn't matter if you drop an elephant or a mouse
∴ we no need to calculate a_1, a_2, a_3 etc. We replace them all with common symbol 'g'.

Now, $$g = \frac{G m_2}{r^2} = \frac{G m_\oplus}{(R+h)^2}$$

$m_\oplus$ = mass of earth
R = radius of earth
h = height of object

$$= \frac{(6.67\times10^{-11}) \times (6\times10^{24})}{((6.4\times10^{6}) + (0.5))^2}$$

All values in SI units

$\approx 9.8\ m/s^2$ (by ignoring little value of $h=0.5m$)

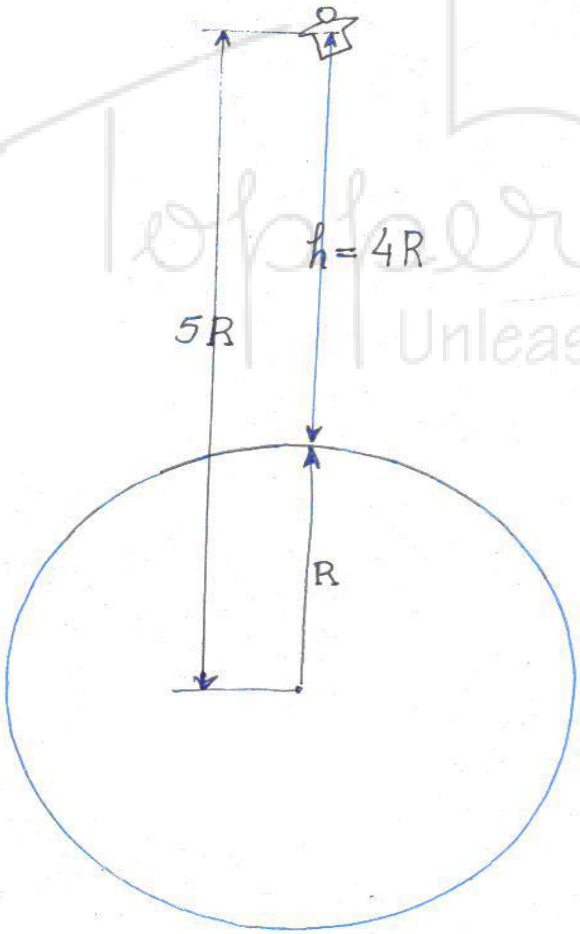
∴ $g = 9.8\ m/s^2$ only if object is very close to the surface of earth. But value of 'g' changes as we go
- very deep inside the earth OR
- very high above earth's surface.

∴ if depth (d) or height (h) is comparable to the radius of earth, it can not be ignored and it affects the value of 'g'.

Effects on gravity

1) due to height
2) due to depth
3) due to rotation of earth
4) due to shape of earth.

Effect of height



$$F = \frac{G m_1 m_2}{r^2} = \frac{G m_1 m_2}{(R+h)^2}$$

if $h = 4R$, $F' = \frac{F}{25}$

$$g' = \frac{g}{25}$$

if $h = \infty$, $F' = \frac{F}{\infty^2} = 0\,N$

$$g' = \frac{g}{\infty^2} = 0\,m/s$$

Hence, 'g' decreases with ~~is~~ increasing height & reduces to zero at infinity.