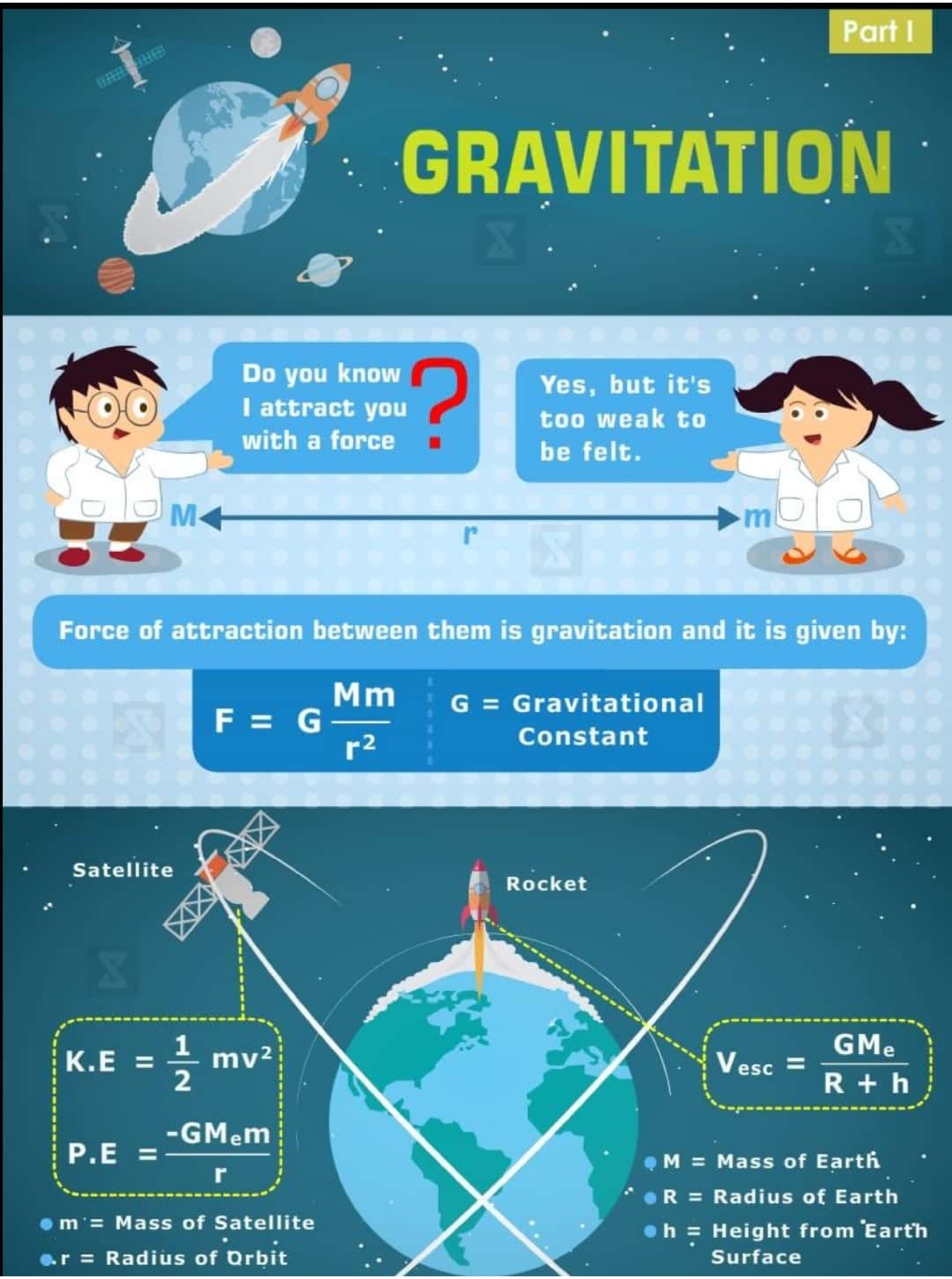
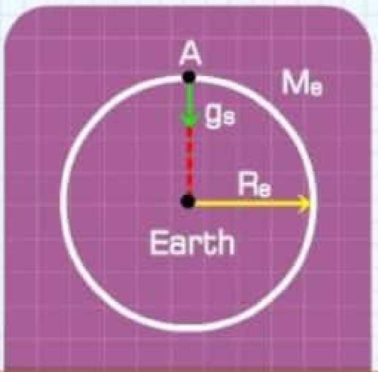

Part I
GRAVITATION
Do you know I attract you with a force?
Yes, but it's too weak to be felt.
M
r
m
Force of attraction between them is gravitation and it is given by:
$F = G\frac{Mm}{r^2}$
G = Gravitational Constant
Satellite
Rocket
$K.E = \frac{1}{2}mv^2$
$P.E = \frac{-GM_e m}{r}$
$V_{esc} = \frac{GM_e}{R + h}$
m = Mass of Satellite
r = Radius of Orbit
M = Mass of Earth
R = Radius of Earth
h = Height from Earth Surface

Part II

GRAVITATIONAL FORCE

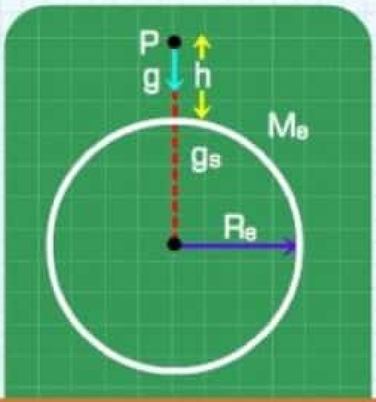
Acceleration Due to Gravity

On the surface of earth



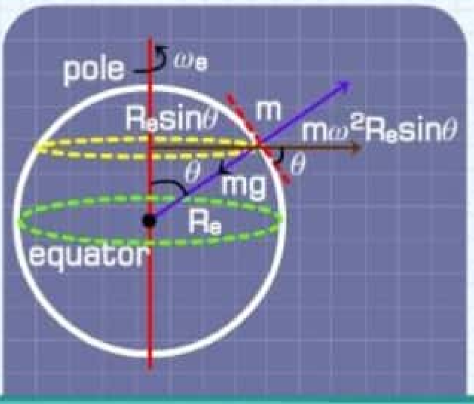
$$g = \frac{GM}{R^2} = 9.81\,ms^{-2}$$

At height h from the surface of earth



$$g' = \frac{g}{\left(1+\frac{h}{R}\right)^2} = g\left(1-\frac{2h}{R}\right) \text{ if } h << R$$

Effect of rotation of earth at latitude

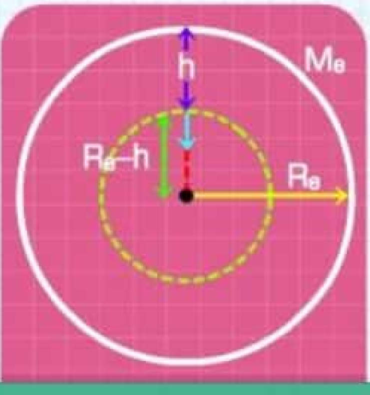


$$g' = g - R\omega^2\sin^2\phi$$

At equator, $\phi = 90^\circ$, $g' - R\omega^2 = 9.78 m/s^2$

At poles, $\phi = 0$, $g' = g = 9.83\ m/s^2$

At depth d from the surface of earth



$$g' = g\left(1-\frac{d}{R}\right)$$

$g' = 0$ if $d = R$ i.e., at centre of earth

- At equator, effect of rotation of earth is maximum and value of g is minimum.
- At poles, effect of rotation of earth is zero and value of g is maximum.

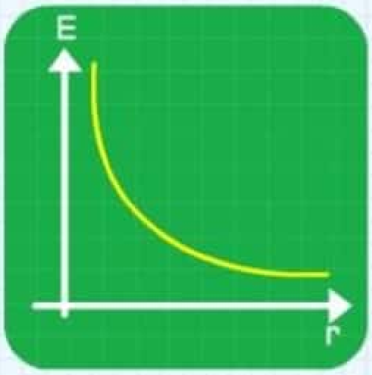
Gravitation Field Strength

Part III

Gravitation field strength at a point in gravitational field is defined as:

$\vec{E} = \frac{\vec{F}}{m}$ = **Gravitational force per unit mass.**

Due to a point mass

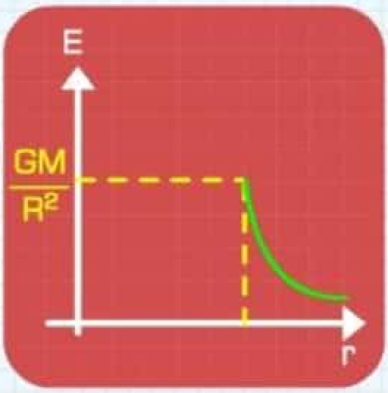


$E = \frac{GM}{r^2}$ (towards the mass)

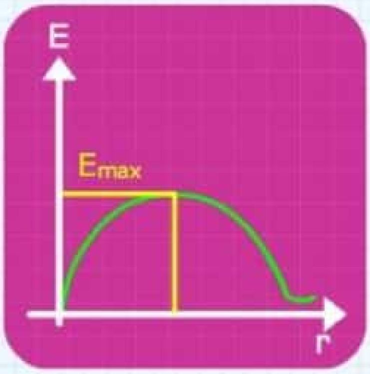
or $E \propto \frac{1}{r^2}$

Due to spherical shell

- Inside points, $E_i = 0$
- Just outside the surface, $E = \frac{GM}{R^2}$; **R - Radius of Sphere**
- Outside Point, $E_o = \frac{GM}{r^3}$; **r - Distance of centre from an external point**
- On the surface E-r graph is discontinuous.



On the axis of a ring



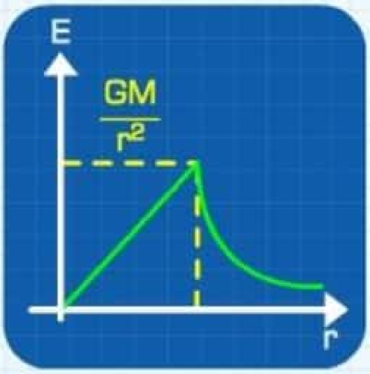
$E_{ix} = \frac{GMx}{(R^2+x^2)^{3/2}}$; At $x = 0$, $E = 0$ i.e., at centre

If $x >> R$, $E = \frac{GM}{x^2}$ i.e., ring behaves as a point mass

At $x \to \infty, E \to 0$; $E_{max} = \frac{2GM}{3\sqrt{3}R^2}$ at $x = \frac{R}{\sqrt{2}}$

Due to a solid sphere

- Inside points $E_i = \frac{GM}{R^3} r$
- At $r = 0$, $E = 0$ i.e. at centre
- At $r = R$, $E = \frac{GM}{R^2}$ i.e., on surface
- Outside points $E_o = \frac{GM}{R^2}$ or $E_o \propto \frac{1}{r^2}$
- At $r \to \infty, E \to 0$

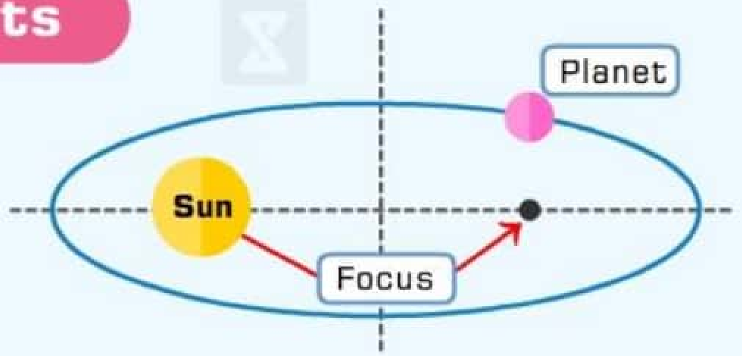


Kepler's law of Planetary Motion

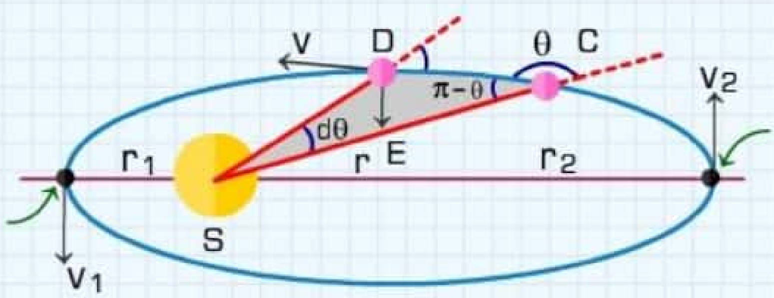
Part IV

1st Law — The Law of Orbits

All the planets move around the sun in elliptical orbits with sun at one of the focus, not at centre of orbit.



The Law of Areas — 2nd Law



The line joining the sun and planet sweeps out equal areas in equal time.

$$\frac{dA}{dt} = \frac{L}{2m} = \text{Constant}$$

3rd Law — The Law of Periods

The time period of revolution of a planet in its orbit around the sun is directly proportionally to the cube of semi - major axis of the elliptical path around the sun.

$$T^2 \propto a^3$$