ZinEdu

Education with Innovative Technology

IIT | JEE | NEET | NTSE | KVPY | OLYMPIADS | BOARDS

Topic-Gravitation
Lecture-01
Karmendra Tyagi

Zinedu hai to...possible hai!

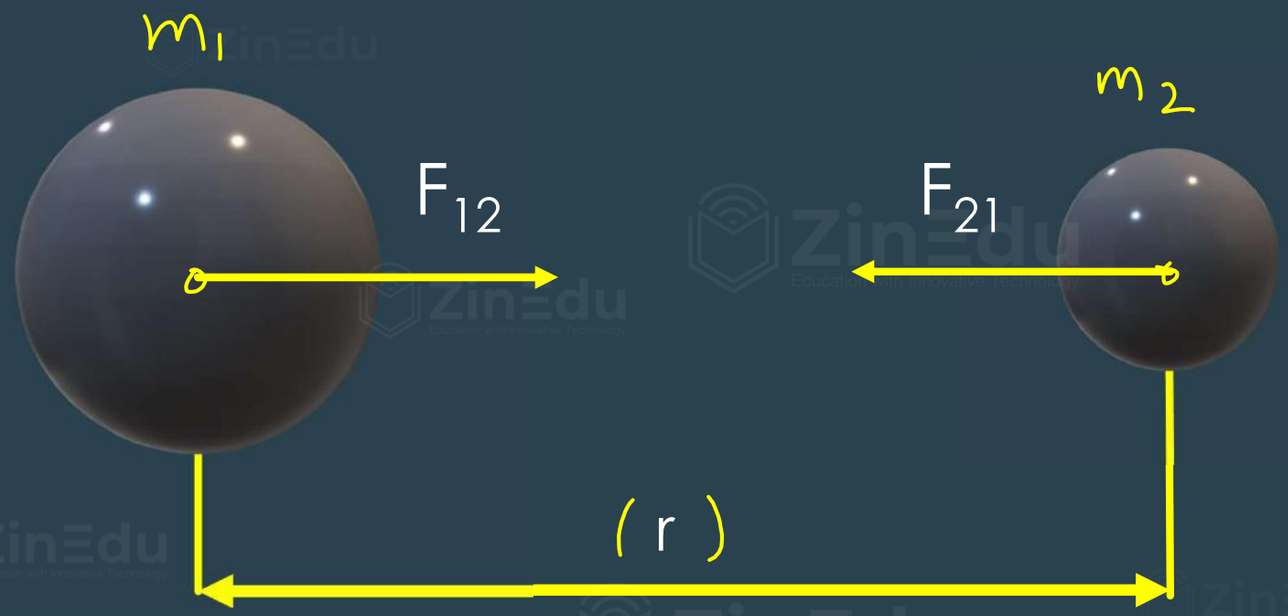
Newton observed that an object, an apple, when released near the earth surface is accelerated . There must be a force pulling objects towards the earth..

It is also observed that moon revolves around the earth in a closed circular path . There must be a force revolving the moon around the earth.

Newton's law of Universal Gravitation

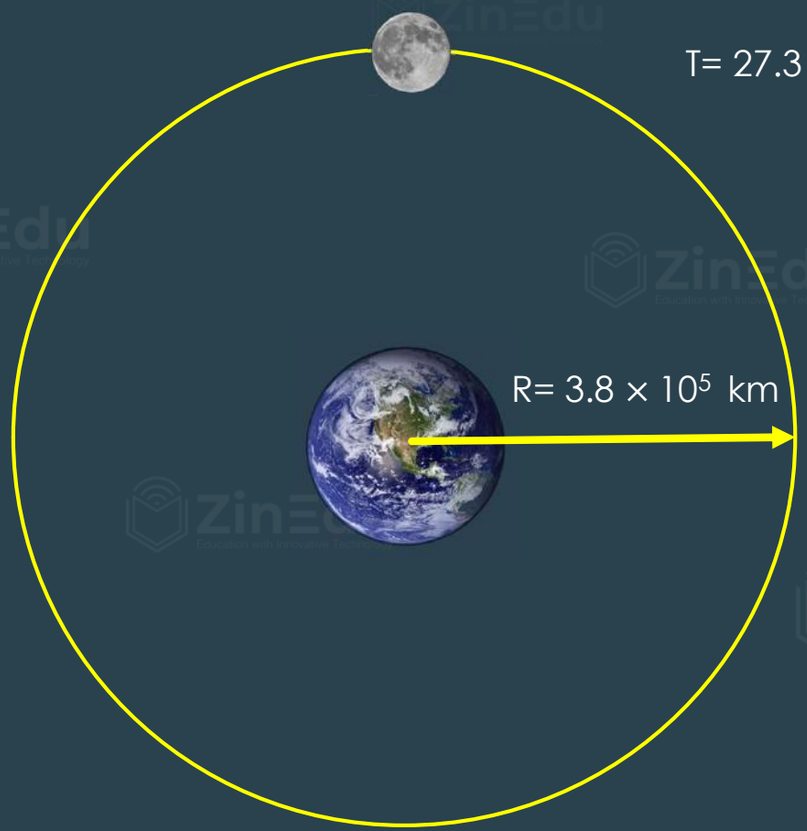
$F_{12} = -F_{12}$

According to Newtons 3rd law of motion the force between two objects are equal and opposite

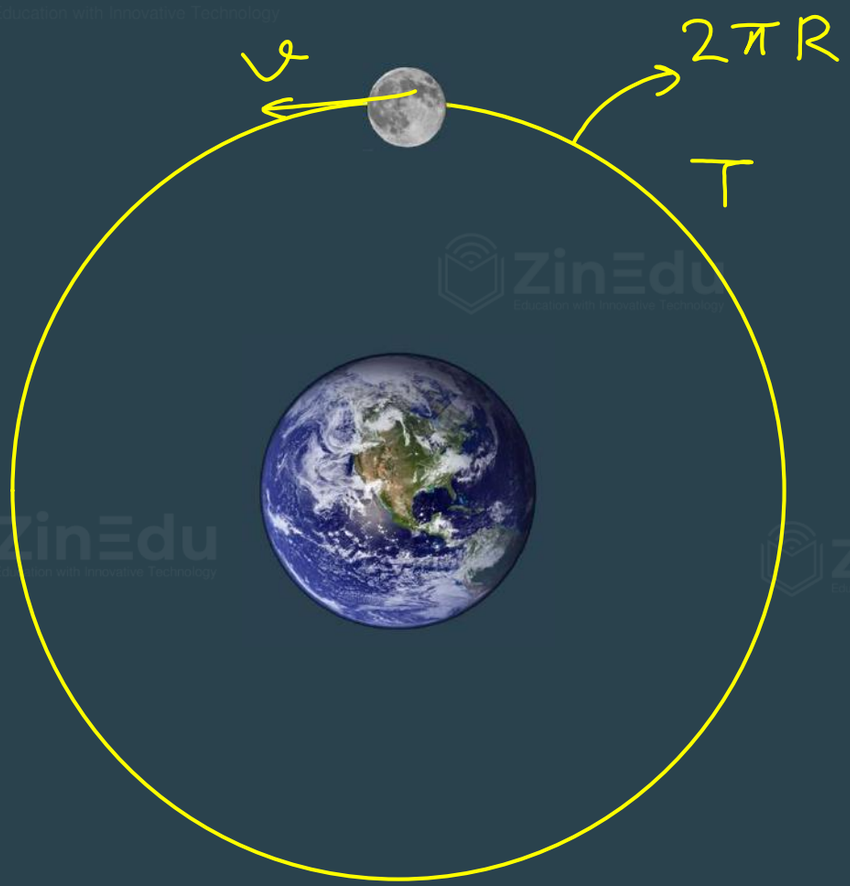


$$F = \frac{G\, m_1 m_2}{r^2} = |\vec{F}_{12}| = |\vec{F}_{21}|$$

Newton's law of Universal Gravitation



Newton's law of Universal Gravitation

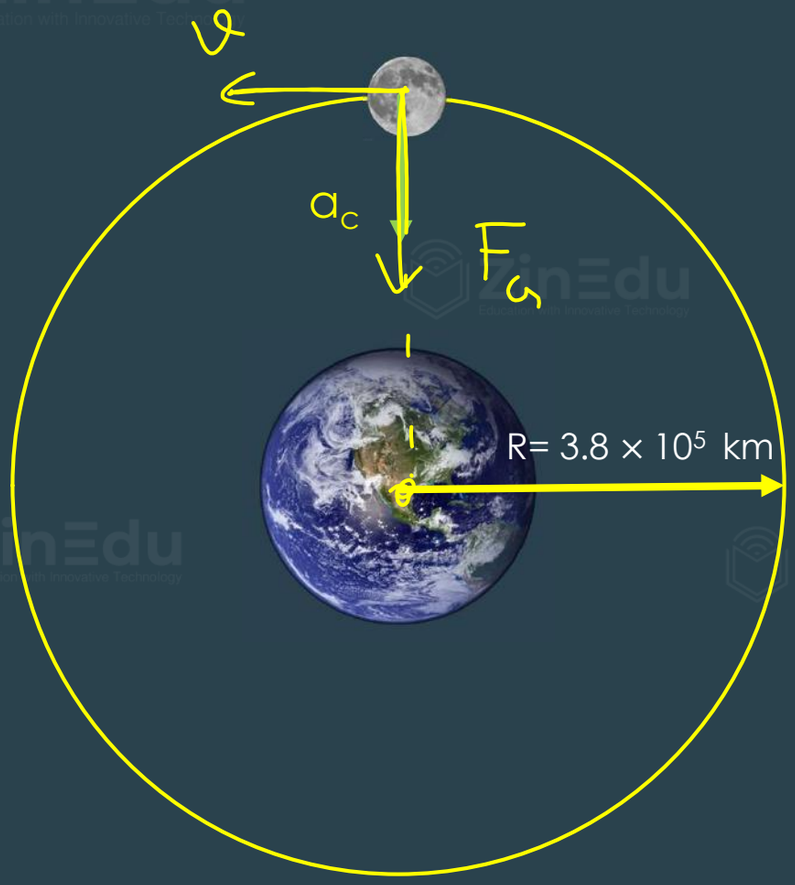


For any particle moving in a circle of radius R with uniform speed v ,

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

here T is time period of revolution .

Newton's law of Universal Gravitation

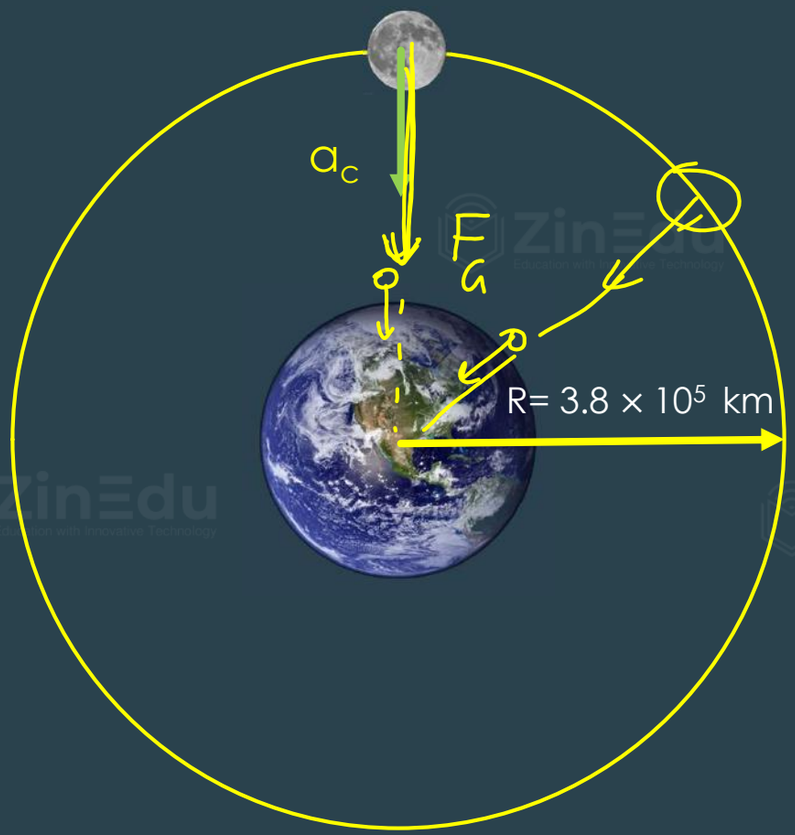


For any particle moving in a circle of radius R with uniform speed v , Its centripetal acceleration

$$\left[a_c = \frac{v^2}{R} \right]$$

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

Newton's law of Universal Gravitation



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

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

$R = 3.8 \times 10^5$ km

T = 27.3 days

Putting the values of R= 3.8 × 10^5 km and T =27.3 days

a_{moon} = 0.0027 m/s^2

Newton's law of Universal Gravitation

Acceleration due to gravity of any object on the Earth's surface

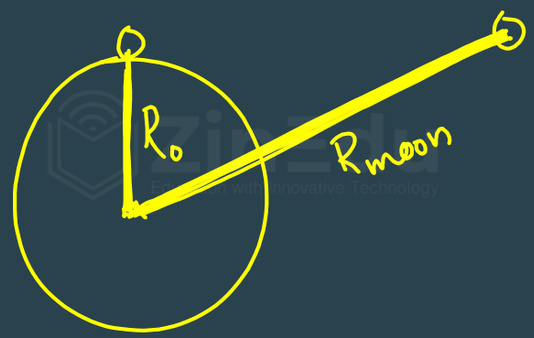
$a_{object} = g = 9.8\ ms^{-2}$

*Video curtesy :BBCtwo Youtube

Newton's law of Universal Gravitation

If we calculate ratio of acceleration of the object on earth to acceleration of moon

$$\frac{a_{object}}{a_{moon}} = \frac{9.8}{0.0027} = 3600$$



Also the ratio of distance of moon from the earth's center to acceleration of the object on earth from earth's center

$$\frac{R_{moon}}{R_{object}} = \frac{3.8\times10^{5}}{6400} = 60$$

↳ Radius of earth.

Newton's law of Universal Gravitation

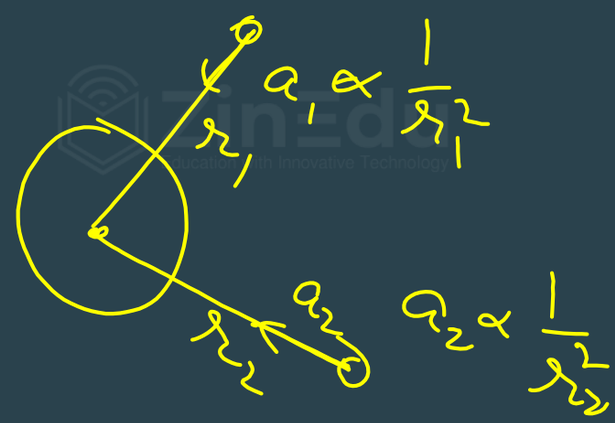
Also the ratio of distance of moon from the earth's center to acceleration of the object on earth from earth's center

$$\frac{R_{moon}}{R_{object}} = \frac{3.8\times10^{5}}{6400} = 60$$

$$\frac{a_{object}}{a_{moon}} = \left[\frac{R_{moon}}{R_{object}}\right]^2$$

(Comparing ...

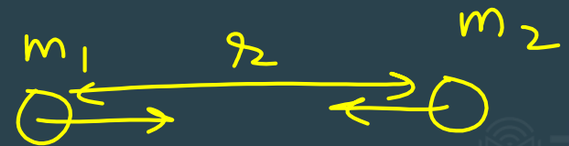
$a \propto 1/r^2$)



Newton's law of Universal Gravitation

$F = ma = m\frac{k}{r^2}$ $\quad a = \frac{k}{r^2}$

$F_G \propto \frac{m}{r^2}$



$F_1 \propto \frac{m_1}{r^2}$ $\quad F_2 \propto \frac{m_2}{r^2}$

Same

$F = \frac{Gm_1m_2}{r^2}$

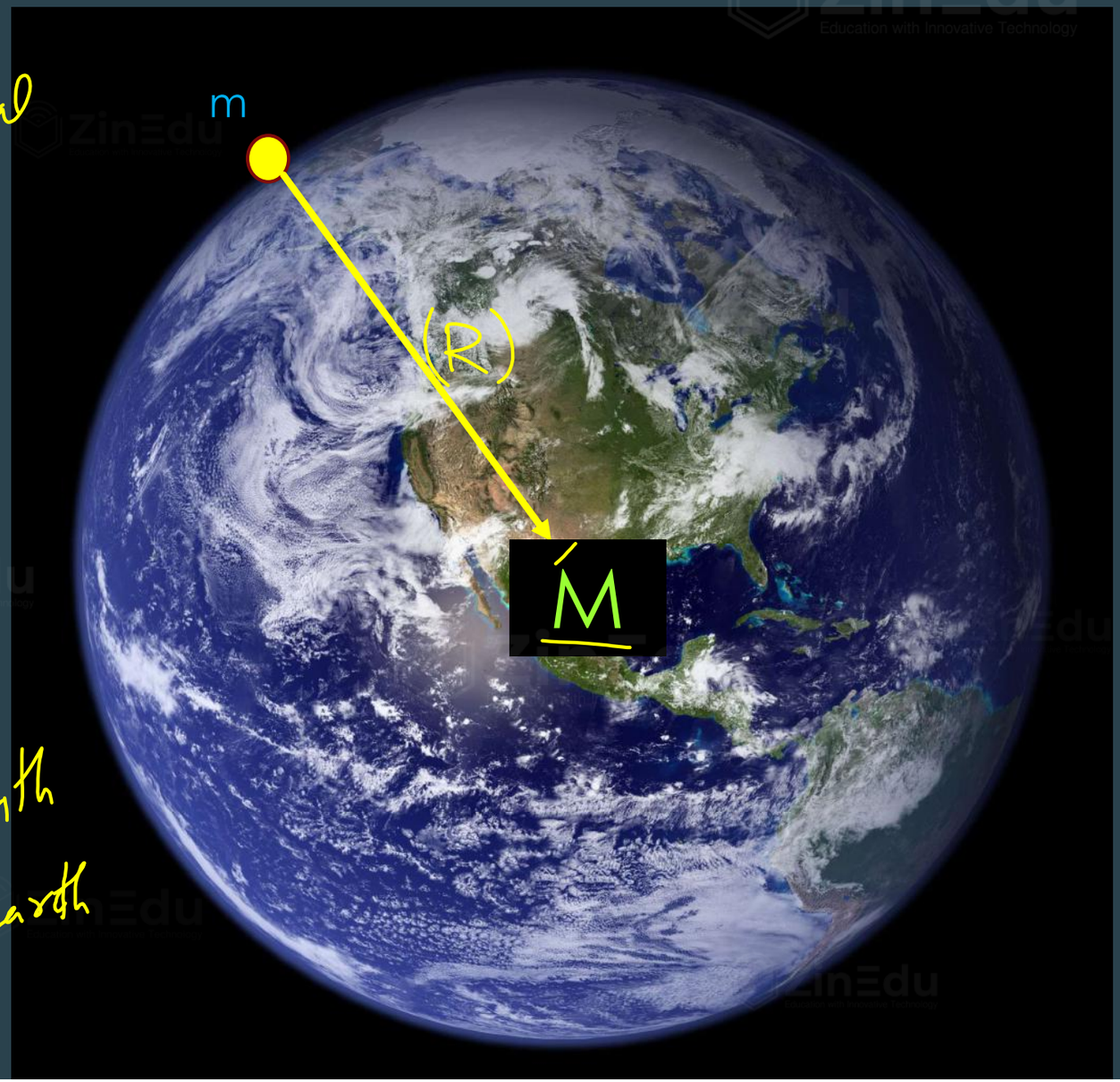
$F \propto \frac{m_1m_2}{r^2}$

G → Universal gravitation Constant $G = 6.67 \times 10^{-11} \frac{N m^2}{kg^2}$ (SI)

Newton's law of Universal Gravitation

F = mg → gravitational force

$$F = \frac{GmM}{R^2} = mg$$



Gravitation field on the earth's surface

field strength (or) acc^{n} due to gravity $(g) = \frac{GM}{R^2}$

M → mass of the earth

R → radius of earth

Newton's law of Universal Gravitation

$g = \frac{GM}{R^2}$

If mass of a planet is four times of mass of the earth and its radius is double of radius of earth find value of the gravitational field on its surface.

$$\frac{g_p}{g_e} = \frac{M_p}{R_p^2} \times \frac{R_e^2}{M_e} = \frac{4M_e}{M_e} \times \frac{R_e^2}{(2R_e)^2}$$

$$\frac{g_p}{g_e} = 1$$

$$g_p = 9.8\ m/s^2$$

Newton's law of Universal Gravitation

If density of a planet is four times of density of the earth and radius is double of radius of earth find value of the gravitational field on its surface

$$g = \frac{GM}{R^2} = \frac{G}{R^2} \rho \times \frac{4}{3}\pi R^3 = \left(\frac{4\pi G}{3}\right)\rho R$$

$$\frac{g_p}{g_e} = \frac{\rho_p R_p}{\rho_e R_e} = \frac{4\rho_e \times 2R_e}{\rho_e R_e} = 8$$

$$g_p = 8 \times g_e = 8 \times 9.8 \ m/s^2$$

Newton's law of Universal Gravitation

If mass of a planet is three times of the mass of earth and its radius is four times of radius of earth find value of the gravitational field on its surface.