DEC 6

Every particle in the universe attracts every other particle with masses

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

G: universal gravitational constant = 6.67×10^{-11} Nm^2/kg^2

① Gravity near the Earth's surface

$r_e = 6.4 \times 10^6$ m $m_e = 5.98 \times 10^{24}$ kg

$F_g = mg$

$g = \frac{F_g}{m}$

$g = \frac{Gm_e}{r^2}$

$g = \frac{(6.67 \times 10^{-11})(5.98 \times 10^{24})}{(6.4 \times 10^6 \text{ m})^2}$

$g = 9.738$ N/kg

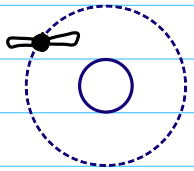
↑ gravitational field strength

② Off Earth

$g = \frac{Gm_e}{(r+h)^2}$

going above the surface
→ lower gravitational field
→ lower gravitational force

③ Satellite



what is the velocity of satellite in UCM a distance r from the centre of Earth?

$$F_c = F_g$$

$$\frac{mv^2}{r} = \frac{Gmm_e}{r^2}$$

$$v^2 = \frac{Gm_e}{r}$$

$$v = \sqrt{\frac{Gme}{r}}$$

④ why are astronauts weightless on the ISS?

weight = normal force opposing gravitational force

If the scale and you are in free fall

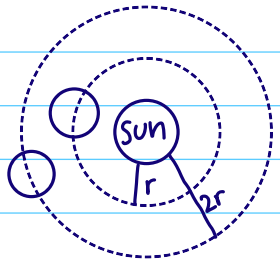
$F_N = 0$

Astronauts are in a form of free fall.

The force of gravity is used to keep you in a circle orbit

DEC 8 Orbiting Bodies

Ex ① A satellite is placed in orbit around sun. The orbital radius of the satellite is twice the orbital radius of Earth. Find the period of the satellite



$T_e = 365 \times 24 \times 60 \times 60 \text{ s}$

$F_c = \frac{m_{sat} 4\pi^2 r_E}{T_E^2}$

$\frac{G m_{sat} m_{sun}}{r_E^2} = \frac{m_{sat} 4\pi^2 r_E}{T_E^2}$

$\frac{G m_{sun}}{4\pi^2} = \frac{r_E^3}{T_E^2}$

anything orbiting sun

$\frac{r_1^3}{T_1^2} = \frac{r_2^3}{T_2^2}$

$\frac{r_{earth}^3}{T_{earth}^2} = \frac{(2r_{earth})^3}{T_{sat}^2}$

$T_{sat} = 2\sqrt{2}\,(T_{earth})$

Ex② You want to hit a volleyball so fast that it orbit the Earth near its surface. What is that velocity?

$m_E = 5.98 \times 10^{24} \text{ kg}$

$r_E = 6.371 \times 10^6 \text{ m}$

$F_c = F_g$

$\frac{mv^2}{r} = \frac{G m m_E}{r^2}$

$v^2 = \frac{G m_E}{r}$

$v = \sqrt{\frac{G m_E}{r}}$

$v = \sqrt{\frac{(6.67 \times 10^{-11})(5.98 \times 10^{24})}{(6.371 \times 10^6)}}$

$v = 7912 \text{ m/s}$