PENANG SANGAM HIGH SCHOOL

WEEK 7 LESSON NOTES

PYHSICS – Y13

STRAND: GRAVITATION
SUB-STRAND: Newton's Law of Gravitation
CONTENT LEARNING OUTCOME: to solve problems with the understanding of the law of Gravitation and its application to satellite motion.

There is a force of attraction between any two particles in this universe, and this phenomena is known as gravitation.

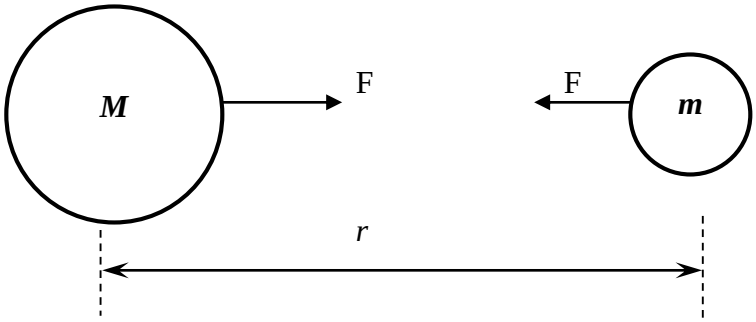
Newton's Law of Universal Gravitation

"Every particle in this universe attracts every other particle with a force which is ***directly proportional to the product of their masses and inversely proportional to the square of the distance between them."***

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

Units : N

G = Universal gravitational constant
= $\mathbf{6.67 \times 10^{-11}\ Nm^2kg^{-2}}$



To derive an expression for the acceleration due to gravity for earth:

Force of gravity = Weight

$\mathbf{F_g} = \frac{GMm}{r^2}$, weight = mg

$\mathbf{F_g}$ = Weight

$\frac{GMm}{r^2}$ = mg (m can be eliminated)

$$\mathbf{g} = \frac{GM}{r^2}$$

Where: **M = mass of earth**
***r* = radius of earth**

To obtain a value for gravitational acceleration:
Mass of earth = 5.98×10^{24} kg , Radius of earth = 6.4×10^6 m

$$g = \frac{GM}{r^2} = \frac{\left(6.67\times10^{-11}\,Nm^2kg^{-2}\right)\left(5.98\times10^{24}\,kg\right)}{\left(6.4\times10^{6}\,m\right)^2} = \underline{9.74\ \text{m/s}^2}$$

The Motion of Satellites

To find the orbital velocity

Equate centripetal force ($\mathbf{f}_c$) equal to gravitational force ($\mathbf{f}_g$)

$$\mathbf{f}_c = \mathbf{f}_g$$

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

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

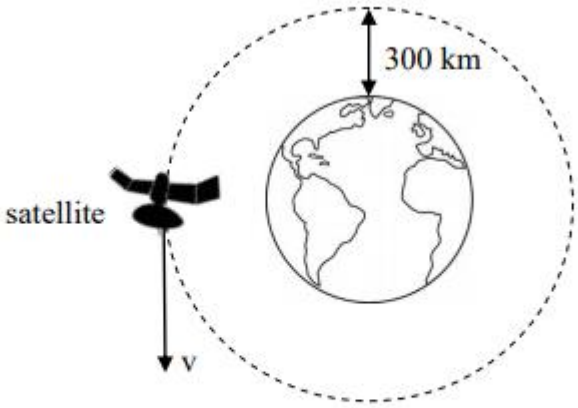
Hence, the orbital speed is given by $\boxed{v=\sqrt{G\frac{M_E}{r}}}$

Note The satellite's mass has no effect on its orbital speed.

The period of the satellite is given by $\boxed{T=\frac{2\pi r}{v}}$

Exercise

(a) A communication satellite is placed in a circular orbit, 300 km above the earth's surface.



Calculate the:

(i) orbital speed of the satellite.

(ii) period of the satellite.

Attempt Question from Y13 Text: Pg 43 , Exercise 1.8 (Q 1)