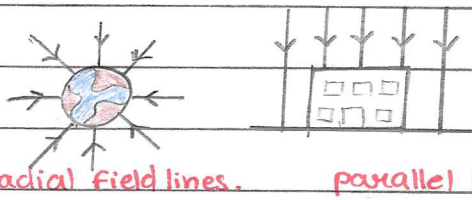
18 - Gravitational Fields

Q-1) What is gravitational field of a force?

> It's the region around a mass where another mass experiences a force.



radial field lines. parallel field lines.

Q-2) What is Newton's law of gravitation?

> Any two point masses attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of their seperation.

$$F = \frac{GMm}{R^2}$$ → $G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$

Q-3) What is gravitational field strength?

> It's the gravitational force exerted per unit mass on a small object placed at that point.

Field strength $g = \frac{GM}{R^2}$ → $\left[g = \frac{F}{m}\right]$

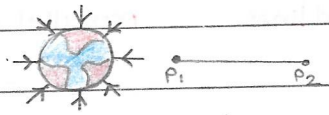
g (Field strength) is also acceleration of free-fall.
$g = 9.81\ ms^{-2}$ at earth's surface.

Q-4) What is gravitational potential?

> It's the work done per unit mass in bringing a mass from infinity to a point in the gravitational field.

$$\phi = -\frac{GM}{R}$$

→ Attractive force ∴ always -ve. as work is got out.



When a mass is moved;

* P_2 to P_1; potential energy decreases (more -ve) as work is got out (towards attractive force).
* P_1 to P_2; potential energy increases (less -ve) as work is got in (against attractive force)

Q-5) What is gravitational potential energy?

> The energy a body has due to its position in the gravitational field.

$$gpe = -\frac{GMm}{R}$$

Q-6) What is the critical velocity of a satellite?

> It's the minimum velocity that should be given to a satellite from a point above the earth's surface so that it moves in a circular orbit around the earth (V_c)

IF:

$V < V_c$; satellite falls to earth

$V = V_c$; satellite follows a circular path

$V > V_c$; satellite follows an elliptical path.

Since gravitational force provides the centripetal force;

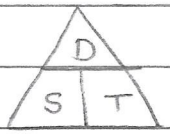
$$\frac{GMm}{R^2} = \frac{mv_c^2}{R}$$

→ Orbital velocity doesn't depend on mass of the satellite

$$\therefore v_c^2 = \frac{GM}{R}$$

Q-7) What is the orbital period?

> It's the time taken for one complete revolution.



$$v = \frac{2\pi R}{T} \quad -①$$ → D = 2πR (circumference)

$$v^2 = \frac{GM}{R} \quad -②$$

→ equate ①² and ②

$$\therefore \frac{4\pi^2 R^2}{T^2} = \frac{GM}{R}$$

$$\therefore T^2 = \frac{4\pi^2}{GM} \times r^3$$

$$\therefore T^2 \propto r^3$$ → Kepler's law of planetary motion.

Q-8) What is the escape velocity of a satellite?

> It's the minimum velocity with which an object must be projected from the earth's surface so that it escapes from the gravitational field. (ve).

Binding energy = kinetic energy

$$\frac{GMm}{R} = \frac{1}{2} m v_e^2$$

$$\therefore v_e^2 = \frac{2GM}{R}$$

$$\therefore v_e = \sqrt{\frac{2GM}{R}}$$

Q-9) What is a geostationary orbit?

> The orbit of a satellite, which has a period equal to one day, so that the satellite remains at the same point on the earth's equator is called a geostationary orbit. *

From the earth, the satellite appears to be stationary.

The satellite recieves signals from the earth, amplifies them back over a large surface area of the earth.

uses:

- communication systems
- transmitting TV signals.

* Geostationary satellite / orbit.

→ It's the orbit of a satellite, above the earth's equator in which the satellite orbits the earth in the same direction as the earth's rotation (west to east) and has the same period as the earth's spin (24 hours).

A satellite on this orbit appears to stationary at a point on the earth.