A Level H2 Physics Tutorial 7: Gravitational Field

Syllabus :
(a) show an understanding of the concept of a gravitational field as an example of field of force and define the gravitational field strength at a point as the gravitational force exerted per unit mass placed at that point

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1. (a) The gravitational force on 2 kg of rice is mg = 19.62 N. Find the gravitational field strength on the rice.

(b) The gravitational field strength on a mass m with weight F is F/m. State the value of F/m on Earth's surface.

(b) recognise the analogy between certain qualitative and quantitative aspects of gravitational and electric fields

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(c) recall and use Newton's law of gravitation in the form $F = Gm_1m_2 / r^2$

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2. (i) Use the law of gravitation to find the force between Earth and 1 kg of milk. Earth's radius is 6400 km.

(ii) Explain how the answer to (i) is related to the acceleration due to gravity, 9.81 m/s^2.

(d) derive, from Newton's law of gravitation and the definition of gravitational field strength, the equation $g = GM / r^2$ for the gravitational field strength of a point mass

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3. Gravitational field strength g at a distance r from the centre of Earth is the force per unit mass at that point. Obtain and expression for g, using Newton's law of gravitation. Let the mass of Earth be M.

(e) recall and apply the equation $g = GM / r^2$ for the gravitational field strength of a point mass to new situations or to solve related problems

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(f) show an understanding that near the surface of the Earth, gravitational field strength is approximately constant and is equal to the acceleration of free fall

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4. The radius of Earth is 6478 km. Mass of Earth is 5.972×10^{24} kg.

Find the gravitational field strength on the surface of Earth.

Comment on how this value is related to the acceleration due to gravity, 9.81 m/s^2.

(g) define the gravitational potential at a point as the work done per unit mass in bringing a small test mass from infinity to that point

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5. (i) State the definition of gravitational potential at a point.

(ii) Write down the formula for gravitational potential at distance r from the centre of a uniform, spherical body of mass M.

(iii) Find the potential of a point 10000 km from the centre of Earth. Mass of Earth is 5.972×10^{24} kg.

(h) solve problems using the equation $\varphi = -GM / r$ for the gravitational potential in the field of a point mass

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(i) analyse circular orbits in inverse square law fields by relating the gravitational force to the centripetal acceleration it causes

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6. Earth is 1.475 x 10^8 km from the Sun. Earth's orbit round the sun is approximately circular, and takes 1 year.

Find the mass of the Sun.

Hint: the centripetal force for Earth's orbit is the gravitational force from the Sun.

(j) show an understanding of geostationary orbits and their application

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7. Calculate the radius of a geostationary orbit of a satellite in a circular orbit round Earth.

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