# Topic 12: Gravitational Fields

## **1.2 Specification notice:**

Mathematical skills that could be developed in this topic include sketching relationships that are modelled by y = k/x, y = k/x2.

## **12.Q Exam questions**

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## **12.174 understand that a gravitational field (force field) is defined as a region where a mass experiences a force**

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| Define gravitational field (force field)? | A region of space where a mass experiences a gravitational force |
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## **12.175 understand that gravitational field strength is defined as and be able to use this equation**

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| What is Gravitational Field Strength and what is the equation for it? (uniform field) | * It is the amount of force something would feel per unit mass (Nkg-1).     *g is the gravitational field strength (Nkg-1), F is the force due to gravity (N), m is the mass of the object (kg)* |
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## **12.176 be able to use the equation (Newton’s law of universal gravitation)**

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| What is the definition of Newton’s Law of Universal Gravitation and whats its equation? | **The gravitational force F between two masses (m1 and m2) is directly proportional to the product of the masses and inversely proportional to the square of the distance between them** **or**  *F is the force between the two objects (N), G is the gravitational constant 6.67x10-11 (also known as big G), m1  and m2 are the masses of the two objects are r is the distance between the centre of masses (m).*  *Big M is the mass that creates the g field*  *A common mistake in exams is to forget to add together the* ***distance from the surface of the planet and its radius*** *to obtain the value of r.* |
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## **12.177 be able to derive and use the equation for the gravitational field due to a point mass**

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| Derive the equation for the gravitational field due to a point mass (radial field) | * ,     *g is the gravitational field strength due to a point mass (Nkg-1), G is the gravitational constant (big G), M is the mass of the object (like the Earth rather than the person, although you can do it vice versa) as gravitational field strength is independent of the mass, r is the distance from the centre of mass M*  *When using the equation for gravitational field strength, remember that the mass M is the mass causing the gravitational field. The mass m is the object that experiences the gravitational field of M.* |
| What does the Gravitational Field Strength v. Distance graph look like and why? | The linear relationship at the start is because the mass below you is what matters (between the centre and r). By combining g=GM/r2 and M=4/3πr3𝜌, you get a linear relationship of g=4/3πG𝜌r |

## **12.178 be able to use the equation for a radial gravitational field**

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| What is Gravitational Potential defined as, with its equation and why does it have a negative sign? | The work done per unit mass to move a mass from point to infinity OR The gravitational potential energy per unit mass (Jkg-1) at a point  *There is a negative sign as work needs to be done to move an object from a point in the field to infinity and so work is done against gravity as well as g is attraction so moving from point to infinity is opposite therefore its negative (since outside the field potential is defined as zero then the potential inside the field must be negative)*  *Where V is the gravitational potential, G is the gravitational constant (big G), M is the mass of the object causing the gravitational field, r is the distance to that mass* |
| What is Gravitational Potential Energy defined as, its equation, and why is it negative? | The work required to move an object from a point (most likely earth) to infinity (where there is no potential).    which is from V=-GM/r and W=GMm / (1/rb-1/ra)  *When moving closer to a mass, positive work is done as GPE changes into KE. When moving away, negative work is done as its against the force of gravity (i.e., KE into GPE).* |
| What is the equation to calculate the escape velocity from a planet (e.g Earth)? [You don’t need to know derivation but its good to remember] | * 1/2mv2 = KE , ΔW=mΔV * 1/2mv2 = mΔV * 1/2v2 = ΔV * v=√2ΔV * v=√(2xGm)/r   *Where v is velocity, V is the grav potential and its from this equation that we know the mass of an object m experiencing a force due to M does not effect the velocity of an object* |
| What does the gravitational potential v. Radius graph look like? |  |

## **12.179 be able to compare electric fields with gravitational fields**

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| What are the 10 differences/similarities between gravitational fields and electric fields | * Origin of force:     They both follow the inverse square law is another similarity |

## **12.180 be able to apply Newton’s laws of motion and universal gravitation to orbital motion.**

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| What are the 2 types of orbits that satellites and planets can do around objects?  What is the advantage of satellites doing an Elliptical orbit instead (2)? | Elliptical orbit   * Allows satellite to get closer to surface so more detailed photographs/scans possible (2) * Allow satellite to spend time further from the surface so prevents exposure to prolonged heat from planet damaging probe (2) * Satellite varies distance from surface so it can take wide angle and close up pictures of the planet (2)   Circular orbits   * Explained on other FC below↓ |
| Describe the 2 different types of circular orbits that satellites do and their purpose? | Geostationary orbit - occurs above the Earth’s equator   * Where a satellite would always be above the same point on the Earth’s surface (1) * So that contact/communication with e.g the space station would be maintained at all times (1) * It has a **period of 24 hours**     Close Polar orbit (or low orbit)   * Where a satellite would always be above the north and south poles of the Earth * Used for monitoring weather, military applications and taking images of Earth's surface, as there is a shorter time delay     *Geostationary occurs at 36000km and polar at 360km above sea level* |
| How can Time period and orbital radius for a satellite in circular orbit be derived? | By equating the centripetal force and gravitational force and approximating the orbit as circular    Also to find orbital period  Also v = 2πr/T  The ratio (r3/T2) will be a constant value for all satellites of the same central body, for example all planets orbtiting the sun it only depends on the mass producing the grav field |

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