HSC PHYSICS

Module 5: Advanced Mechanics

Week 4

Motion in Gravitational Fields I

HOMEWORK

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SPECIALIST TUITION

1 Which of the following statements best explains why the formula for acceleration due to gravity on an object does not depend on the object's mass?

A. The object's mass contributes both to higher force and to lower acceleration from the force; these effects cancel out.

B. Acceleration due to gravity is always constant at any point in space, as long as it is always measured with reference to the same central body.

C. Universal gravitation in general only depends on the mass of the larger body, not the smaller one.

D. Because orbital periods are constant, and determined by gravitational acceleration, there cannot be any mass dependence.

2 Which of the two formulae below, equated together, allow the derivation of Kepler's Third Law of Planetary Motion?

A. Universal Gravitation and centripetal force.

B. Gravitational acceleration and centripetal acceleration.

C. Period in terms of distance over speed, and period in terms of angular frequency.

D. Velocity in terms of distance over period, and orbital velocity.

3 Complete the following statement. The Moon and the International Space Station have the same …

A. Gravitational acceleration.

B. Ratio of the cube of orbital radius to square of orbital period.

C. Sector area subtended from the Earth to their orbital path over equal time periods.

D. Orbital shape.

4 If the Moon has a mass approximately 80 times lower than the Earth and a diameter approximately 4 times smaller than the Earth, what is the value of gravitational acceleration at the Moon's surface in terms of g (the gravitational acceleration at the surface of the Earth)?

A. $\frac{g}{20}$

B. $\frac{g}{6}$

C. $\frac{g}{5}$

D. $4g$

5 Which of these would not affect the acceleration due to gravity you feel while standing on the Earth's surface?

A. Your proximity to the equator.
B. Your proximity to the poles.
C. Your proximity to the Prime Meridian.
D. Your proximity to the stratosphere.

Question 6 (14 marks)

The Earth orbits the Sun over a period of 1 year (365 days). The Sun has a mass of 2×10^{30} kg.

(a) Calculate the Earth's orbital radius. **2**

(b) Calculate the Earth's orbital velocity. **1**

(c) Calculate the mass of the Earth if its radius is 6371 km and acceleration due to gravity on the surface is 9.81 m/s^2. **1**

(d) Hence, calculate the force of gravity with which the Earth and Sun attract each other, and thus the magnitudes of acceleration due to gravity on each body. Discuss the significance of the values you obtain. **4**

(e) A year on the planet Neptune is 165 times longer than a year on Earth. What is Neptune's orbital velocity? **3**

(f) Calculate the orbital radius and orbital speed required for a research satellite placed in Solar orbit to have an orbital period of 100 days. **3**

Question 7 (5 marks)

A gravity null point is the point between two large masses at which their gravitational fields cancel out, and at which a small object would therefore feel no net gravitational attraction. We will call the gravity null point between the Earth and the Sun G_{null}.

(a) Does G_{null} lie closer to the Sun or the Earth? Justify your answer. **2**

(b) Calculate the distance between G_{null} and the centre of the Earth, if the distance from the Earth to the Sun is 1 astronomical unit (1 AU). Note the mass of the Earth is 6.00×10^{24} kg and the mass of the Sun is 1.99×10^{30} kg. **3**

Question 8 (6 marks)

(a) State Kepler's three Laws of Planetary Motion. **3**

(b) Using a diagram, explain what Kepler's second law implies about the orbital velocity of a planet orbiting the Sun. **3**