Year 12 Physics Test NAME_____

Gravitation and Satellites (+ Banking Angle)

1. The speed and period of a GoldenEye satellite around Earth depends only on the radius of orbit and the mass of the Earth, and not on the mass of the satellite.

   (a) Using the equations $T = \frac{2\pi r}{v}$ and $v = \sqrt{\frac{GM}{r}}$, derive the equation $r = \sqrt[3]{\frac{T^2 GM}{4\pi^2}}$ /2

   (b) Hence, if a GoldenEye satellite is in geostationary orbit, show that the radius of its orbit must be 4.23×10^7 m, given that the mass of the Earth is 5.98×10^{24} kg. /2

   (c) Hence calculate the orbital speed of the GoldenEye satellite. /2

2. The fictional planet Coruscant was once ringed with many satellites in various orbits.

   (a) State and explain whether a geosynchronous (geostationary) orbit or a low-altitude polar orbit would be more appropriate for a meteorology and surveillance satellite. /2

   (b) Explain the advantage of launching low-altitude equatorial-orbit satellites in a west-to-east direction. /2

3. The Forest Moon of Endor, with the same mass as Earth's moon, is in circular orbit around the planet Endor with the same radius of orbit as that of Earth's moon around Earth.

   (a) Explain why the centre of a moon's orbit must coincide with the centre of mass of the planet. Assume the moon's orbit around the planet is circular. /2

   (b) Endor's mass is four times Earth's mass, and the force of the Earth's gravitational attraction for Earth's moon is 2.03×10^{20} N.
   Using proportionality, determine the gravitational force on the Forest Moon of Endor exerted by Endor. /3

   (c) Explain how the forces exerted by Endor and its Forest Moon on each other are consistent with Newton's third law. /2

TOTAL /17

The rest of the test is optional.

4. A DeLorean (pictured below) is able to travel at higher speeds around banked corners than around corners on a flat road.

   (a) Draw and label the four forces acting on the DeLorean if it is travelling at constant speed. /2

   (b) With the aid of a diagram, explain how banking a curve decreases the reliance upon friction between the DeLorean's tyres and the road. /4

   (c) Hence show that the relationship between the banking angle, the speed of the DeLorean and the radius of the curve when no centripetal acceleration is provided by friction can be given by $\tan\theta = \frac{v^2}{rg}$. /3

TOTAL /26