Assignments: Gravitational Fields
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1. **The gravitational field strength of an unknown planet is 22 N/kg on its surface. Calculate the value of *g* if the planet's mass and radius were both doubled. (5 marks)**

- We are given the field strength of the surface.
  $g = \frac{GM}{R^2} = 22N/kg$
  Now, when $M' = 2M,\ R' = 2R$ as given in the question above, we can rewrite as the following.
  $g' = \frac{k(2M)}{(2R)^2} = \frac{2}{4}\frac{KM}{R^2} = \frac{1}{2}\frac{KM}{R} = \frac{1}{2} \times (22N/kg) = 11N/kg$

  Thus, the gravitational field strength would be $11N/kg$.

2. **Calculate the period of a planet in the sun system if its radius of orbit around the sun is $7.87 \times 10^{11} m$. Use $k = 3.355 \times 10^{18} m^3/s^2$. (5 marks)**

- Given that the $radius = 7.87 \times 10^{11} m$.
- We can write 'Time period', $radius$: $\frac{R^3}{T^2} = k$
  $T = (\frac{R^3}{k})^{\frac{1}{2}} = [\frac{(7.87\times10^{11})^3}{3.355\times10^{18}}]^{\frac{1}{2}} = 3.81 \times 10^8\ seconds$
  Thus, the period of a planet would be $T = 3.81 \times 10^8\ seconds$

3. **How much additional energy is needed to fire a 7.8102 kg weather monitor on the Earth's surface to a height of 190 km above the Earth? Assume that the weather monitor rises to that height, stops, and falls back to Earth.**

- We can think of extra energy, E, as a change in potential energy, which is the difference with the total energy at height h in addition to the radius of earth and the total energy at the surface of the earth.
  $\Delta E = (-\frac{GMm}{Re+h}) - (-\frac{GMm}{Re}) = GMm(-\frac{1}{Re+h} + \frac{1}{Re})$
  $\Delta E = \frac{(6.67\times10^{-11})(5.98\times10^{24})(7.8\times10^{2})}{10^6}[\frac{1}{6.38} - \frac{1}{6.57}]$
  $\Delta E = (3.11 \times 10^{11})(0.004533) = 1.4097 \times 10^9 J$
  Thus, the answer would be $1.4097 \times 10^9 J$.

4. **A 1400 kg satellite is in orbit around the earth at an altitude of 3900 km. Calculate its total energy. (5 marks)**

- Given that the height h is 3900km, we can write the total energy of the satellite.
  $E_{total} = E_k + E_g$

$$E_{total} = \frac{1}{2}mv^2 + (-\frac{GMm}{R_e+h})$$

To find the velocity,

$$F_g = \frac{mv^2}{Re+h}$$

$$\frac{GMm}{(Re+h)^2} = \frac{mv^2}{Re+h}$$

$$v^2 = \frac{GM}{Re+h}$$

Then,

$$E_{total} = \frac{1}{2}m(\frac{GM}{Re+h}) + (-\frac{GMm}{R_e+h})$$

$$E_{total} = \frac{1}{2}(1400)(\frac{(6.67\times10^{-11})(5.98\times10^{24})}{6.38\times10^6+3900\times10^3}) + (-(\frac{(6.67\times10^{-11})(5.98\times10^{24})(1400)}{6.38\times10^6+3900\times10^3}))$$

$$E_{total} =- 2.716 \times 10^{10}J$$