YEAR 12 PHYSICS. ASSIGNMENT #5. Due Monday 22nd November

Q1. The *escape velocity* of a body from the surface of a planet (etc.) is defined to be the *minimum* velocity it would require to reach a "height" of infinity. At that point the escaping body would have stopped, so its kinetic energy there would be zero, as would be its gravitational potential energy, i.e. $E_{TOTAL} = E_K + E_P = 0$

(a) Given that $E_P = -\frac{GMm}{r}$ and that $E_K = \frac{1}{2} m v^2$, show that the escape velocity of any object (ignoring any force other than gravitation) is given by $v_{ESC} = \sqrt{\frac{2GM}{r}}$ **[2]**

(b) Determine the escape velocity of an atom of hydrogen from the surface of:

- the Sun [$m_{SUN} = 1.99 \times 10^{30}$ kg, $r_{SUN} = 6.96 \times 10^8$ m]; **[2]**
- the Moon [$m_{MOON} = 7.35 \times 10^{21}$ kg, $r_{MOON} = 1.74 \times 10^6$ m]; **[2]**
- Uranus [$m_{URANUS} = 8.66 \times 10^{25}$ kg, $r_{SUN} = 2.56 \times 10^7$ m]. **[2]**

Q2. (a) Discuss "weightlessness", as experienced by astronauts in low-Earth orbits. **[3]**

(b) When I use a data-logger to measure the intensity of an infra-red ray-lamp at a distance of 10.0 metres, I find it registers 1440 units. Determine its intensity, measured in the same units, from a distance of: i/ 30.0 m; ii/ 80.0 m; iii/ 4.0 m. **[4]**

(c) With the aid of a neat diagram explain the causes and effect of "orbital decay". **[4]**

(d) Determine the gravitational potential energy and the kinetic energy of a 70 000-kg Space Shuttle in an orbit (assumed to be circular) 130 km above the ground. **[4]**

(e) Compare this with the total mechanical energy ($E_P + E_K$) of the same Space Shuttle after it has come to rest on the ground at Williams Air Force Base in Arizona – how much energy has been lost, and in which main way has it been lost? **[4]**

(f) Explain the significance of the following on the successful arrival on the landing-strip of a Space Shuttle that has been orbiting the Earth:-

(i) the entry corridor; (ii) wings; (iii) flaps; (iv) a blunt nose;
(v) a surface of tiles having high melting point, and "**ablation**". **[6]**

Q3. (a) Identify four discoveries made by Konstantin Tsiolkovski, related to rocketry research. **[4]**

(b) Identify four techniques developed by Robert Goddard, concerning rocketry research. **[4]**

(c) Contrast the approaches of these rocket pioneers – identify and compare at least three distinct relevant points. **[6]**

(d) "Konstantin Tsiolkovski's work gave the U.S.S.R. a decisive advantage in the space-race." Justify this statement. **[3]**