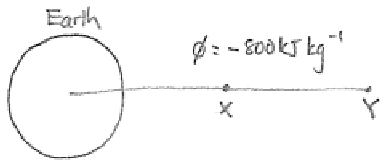
Tutorial 7B Self-Review Suggested Solutions

S1 D



> ***Remember that since gravitational force is attractive in nature, and potential at infinity is taken to be zero, the gravitational potential at a point is always negative.***
>
> ***You should develop the "feel" that when an object is brought nearer to source mass, the GPE will be more negative, when the object is brought away from the source mass, the GPE will increase towards zero.***
>
> ***Can you sketch the GPE- distance graph?***

$\varphi = -GM/r$

$\varphi_Y = \frac{1}{2}\varphi_X = \frac{1}{2}(-800) = -400$ kJ kg^{-1}

Work done by external force = change in gravitational potential energy

$= m(\varphi_Y - \varphi_X)$

$= 3\,[-400 - (-800)]$

$= +1200$ kJ (the positive sign indicates that the mass gains GPE)

S2 Increase in GPE = final GPE – initial GPE

$= -[G(Mm)/(6{,}370{,}000 + 92{,}000)] - [-G(Mm)/(6{,}370{,}000)]$

$= 7.22 \times 10^8$ J

The trickier questions often give the "height of the mass above surface of the Earth" When applying the formula for gravitational force or potential energy, you should always consider the distance between the two masses i.e. (Earth radius + height).

S3

Lowe and Rounce, 3rd Edition. Pg 86, Ex 12.3. Q2.

(a) Gravitational potential of the moon at its surface

$\phi_{moon} = -G\dfrac{M_{moon}}{R_{moon}}$

$= \dfrac{-(6.67\times10^{-11})(7.7\times10^{22}\text{ kg})}{(1.7\times10^{6}\text{ m})}$

$= -3.02\times10^{6}$ kg^{-1} J # ←

Negative sign is Necessary.

(b) By C.O.E, (assuming no ΔK.E → start from rest → go to rest).

∴ WD = increase in P.E $\phi_\infty = 0$

$= \Delta U = U_f - U_i = m\cancel{\phi_f} - m\phi_i$

$= -m\phi_i (= \phi_{moon})$

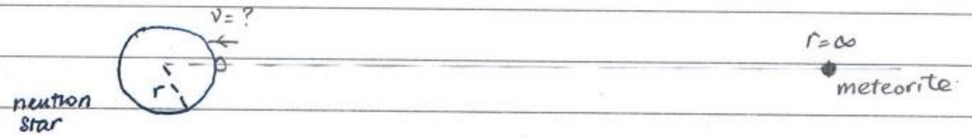
$= -(1.5\times10^{3}\text{ kg})(-3.02\times10^{6}\text{ J kg}^{-1})$

$= 4.53\times10^{9}$ J #

S4

Lowe and Rounce. 3rd Edition. Pg 86. Ex 12.3. Q4

Assume that the meteorite came from infinitely far away



Total energy is conserved

$\Rightarrow \cancel{K.E_{\text{initially at } \infty}}^{\,0} + \cancel{G.P.E_{\text{initially at } \infty}}^{\,0} = K.E_{\text{final at surface}} + G.P.E_{\text{final at surface}}$

$$\Rightarrow 0 = \frac{1}{2}\cancel{m}v^2 - \frac{GM\cancel{m}}{r}$$

$$\Rightarrow v = \sqrt{\frac{2GM}{r}}$$

$$= \sqrt{\frac{2(6.67\times10^{-11})(2.5\times10^{29}\,kg)}{(10\times10^{3}\,m)}}$$

$$= 5.77\times10^{7}\ m/s$$

Alternatively, you could take: Decrease in GPE = Iecrease in KE from infinity to surface.

Always remember that we set gravitational potential = 0 at infinity.

Make sure you are familiar with the definition of gravitational potential, gravitational potential energy and be able to explain why the gravitational potential is always negative.

S5

Firstly, since $GPE = -\frac{GMm}{r}$, we can figure out that the GPE of the second satellite (being at twice the distance away), is -1.6 MJ.

Next, recall that total energy of a satellite is related to the GPE by a factor of 2. More specifically $TE = GPE + KE = \frac{1}{2}GPE$, so total energy of second satellite is -0.8 MJ.

Note that the <u>energy analysis is specifically on satellites in orbits</u>, which is different from projecting a mass away from the Earth (see S3). Can you also sketch the KE-radius, GPE-radius and Total energy-radius graphs? (refer to lecture example on page 28)