Source: [[KBPHYS360MasterIndex]]

1 | **Problem 1**

1.1 | $(1a)$

$$PE = -W$$
$$W = \int_{R_e}^{\infty} F(r)\,dr$$

We know that the force applied to a point mass m by the gravitational field of the earth (with mass M_e) with distance x is modeled by

$$F(r) = \frac{GmM_e}{r^2}$$

. Therefore, our work integral can be modified to be

$$\begin{aligned} W &= \int_{R_e}^{\infty} \frac{GmM_e}{r^2}\,dr \\ &= GmM_e \int_{R_e}^{\infty} \frac{1}{r^2}\,dr \\ &= GmM_e[-\frac{1}{r}]_{R_e}^{\infty} \\ &= -\frac{GmM_e}{R_e} \\ PE &= \frac{GmM_e}{R_e} \end{aligned}$$

1.2 | $(1b)$

$$\begin{aligned} KE &= \frac{1}{2}mv^2 \\ KE &= PE \\ \frac{1}{2}mv^2 &= \frac{GmM_e}{R_e} \\ v &= \sqrt{\frac{2GM_e}{R_e}} \end{aligned}$$

1.3 | $(1c)$

$$\begin{aligned} v &= \sqrt{\frac{2GM_e}{R_e}} \\ &= \sqrt{\frac{2 \cdot 6.674 \cdot 10^{-11} \cdot 5.97210^{24}}{6.371 \cdot 10^{6}}} \\ &= 11185.7 m/s \\ &= 25020.1 mph \end{aligned}$$

2 | **Problem 2**

$$\begin{aligned}
\sum_{i=1}^{n} \vec{F}_{net,i} &= (\sum_{i=1}^{n} m_i)\ddot{\vec{r}}_{CM} \\
\sum_{i=1}^{n} m_i \ddot{\vec{r}}_i &= (\sum_{i=1}^{n} m_i)\ddot{\vec{r}}_{CM} \\
\int\int \sum_{i=1}^{n} m_i \ddot{\vec{r}}_i \, dt \, dt &= \int\int (\sum_{i=1}^{n} m_i)\ddot{\vec{r}}_{CM} \, dt \, dt \\
\int \sum_{i=1}^{n} m_i \dot{\vec{r}}_i \, dt + C_1 &= \int (\sum_{i=1}^{n} m_i)\dot{\vec{r}}_{CM} \, dt + C_1 \\
\sum_{i=1}^{n} m_i \vec{r}_i + C_1 t + C_2 &= (\sum_{i=1}^{n} m_i)\vec{r}_{CM} + C_1 t + C_2
\end{aligned}$$

Both constants are the same constant on both sides of the equation so they will cancel out. The sum of all mass is just M.

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$$\vec{r}_{CM} = \frac{1}{M}\sum_{i=1}^{n} m_i \vec{r}_i$$

3 | **Problem 3**

Any force within a system will have an opposite force applied as well (Newton's 3rd law). Therefore, forces within a system will cancel out and will have no effect on the center of mass.

4 | **Problem 4**

$$\begin{aligned}
\vec{v} &= \frac{< 1,4,1 > +2 < 3,2,6 > +3 < 2,5,3 > +4 < 2,4,6 >}{1+2+3+4} \\
&= < -0.7, 2.3, 2.8 >
\end{aligned}$$

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