Source: [[KBPHYS360MasterIndex]]

1 | **Problem 1**

1.1 | $(1a)$

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

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 | $(1c)$

$$
\begin{aligned}
v &= \sqrt{\frac{2GM_e}{R_e}} \\
&= \sqrt{\frac{2 \cdot 6.674 \cdot 10^{-11} \cdot 5.97210^{24}}{6,371^2}} \\
&=
\end{aligned}
$$

2 | **Problem 2**

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

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.

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

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**

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

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