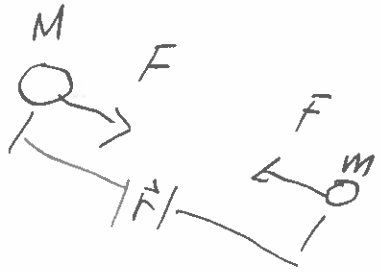
PHYS 1311 Spring 2016

Chapter 3 problems

Problems P11, P23, P27, P39, P43, P47, P55 1-31-2016

Problem P11



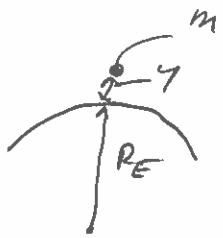
$$|\vec{F}_{grav}| = \frac{GMm}{|\vec{r}|^2} = F$$

$|\vec{r}| = r$

$r_2 = 4r, \quad m_2 = 3m$

$$\Rightarrow \text{New Force} = \frac{GM(3m)}{|4r|^2} = \frac{3GMm}{16r^2} = \boxed{3F/16}$$

Problem P23 what's given



$$\frac{GM_E m}{(R_E+y)^2} = 0.99\,\frac{GM_E m}{R_E^2} = 0.99g$$

$$(R_E+y)^2 = \frac{R_E^2}{0.99} \quad \text{or} \quad R_E^2 + y^2 + 2R_E y = \frac{R_E^2}{0.99}$$

or $0.0101R_E^2 - y^2 - 2R_E y = 0$

or $y^2 + (2R_E)y - 0.0101R_E^2 = 0$

or $y = \frac{-(2R_E)}{2} \pm \sqrt{4R_E^2 + 4(1)(0.0101R_E^2)}$

$= -R_E \pm \sqrt{1.0101R_E^2} = -R_E \pm 1.005R_E$

$= 0.005R_E, \; -2.005R_E = 0.005(6.4\times10^6\,m)$

$$\boxed{y = 3.2\times10^4\,m}$$

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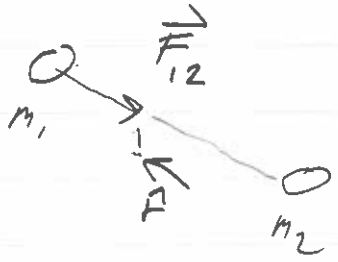
Problem P27



$t_1 = 532\,s$

$m_1 = 1400\,kg$

$\vec{r}_{i1} = \langle 3, 7, -47 \rangle \times 10^5\,m$

$m_2 = 7 \times 10^{15}\,kg$

$\vec{r}_{i2} = \langle 9, -3, -12 \rangle \times 10^5\,m$

a) $\vec{F}_{12} = -\dfrac{G m_1 m_2}{|\vec{r}|^2}\hat{r}$ $\qquad \vec{r} = \vec{r}_1 - \vec{r}_2$

$\vec{r} = \langle 3, 7, -47 \rangle \times 10^5 - \langle 9, -3, -12 \rangle \times 10^5\,m = \langle -6, 10, 87 \rangle \times 10^5\,m$

$|\vec{r}| = \sqrt{6^2 + 10^2 + 8^2} = 14.142 \times 10^5\,m$

$\hat{r} = \dfrac{\vec{r}}{|\vec{r}|} = \langle -0.4243, 0.7071, 0.5659 \rangle$

$\vec{F}_{12} = -\dfrac{\left(6.674 \times 10^{-11}\,\frac{N m^2}{kg^2}\right)(1.4 \times 10^3\,kg)(7 \times 10^{15}\,kg)}{(14.142 \times 10^5\,m)^2}\hat{r}$

$= -3.2703 \times 10^{-4} \langle -0.4243, 0.7071, 0.5659 \rangle$

$\vec{F}_{12} = \langle 1.39, -2.31, -1.84 \rangle \times 10^{-4}\,N$

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Problem P27 (cont'd)

b) $t_f = 538.0$, $\Delta t = 538 - 532 = 6s$

$\Delta\vec{p} = \vec{F}\Delta t = \langle 1.39, -2.31, -1.847 \times 10^{-4} N\ (6s)$

$\boxed{\Delta\vec{p} = \langle 8.34, -1.39, -1.107 \times 10^{-3}\ kg\ m/s}$

Problem P39

$m_e = 9.109 \times 10^{-31}\ kg$

$|e| = 1.602 \times 10^{-19}\ C$

$G = 6.67 \times 10^{-11}\ Nm^2/kg^2$

$k_e = 8.99 \times 10^{9}\ Nm^2/C^2$

$F_e = \dfrac{k_e q_1 q_2}{r^2} = \dfrac{(8.99 \times 10^{9})(-1.602 \times 10^{-19})(-1.602 \times 10^{-19})}{(1 \times 10^{-10}\ m)^2}$

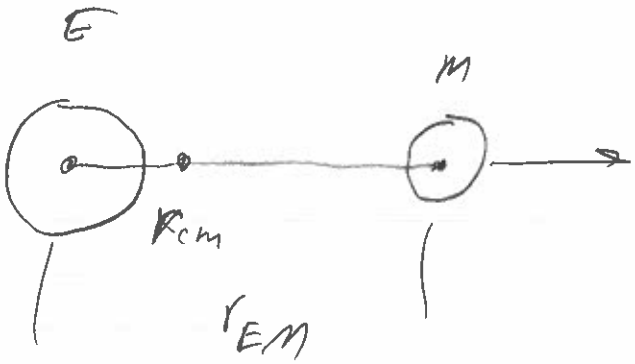
$\boxed{F_e = 2.307 \times 10^{-8}\ N}$

$F_G = \left(6.67 \times 10^{-11}\right)\left(\dfrac{9.109 \times 10^{-31}}{1 \times 10^{-10}}\right)^2 = 5.53 \times 10^{-51}\ N$

Repls.vp

2-16-2016

Problem P43



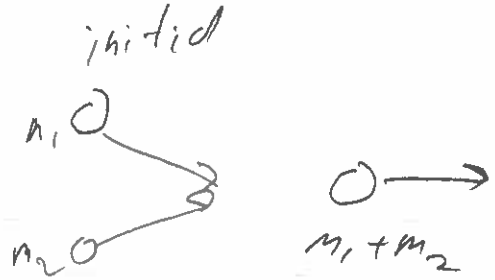
$m_E = 6 \times 10^{24}$ kg
$m_m = 7 \times 10^{22}$ kg
$r_{EM} = 4 \times 10^8$ m

$$r_{cm} = \frac{m_E \cdot 0 + m_m r_{EM}}{m_E + m_m} = \frac{(7\times10^{22})(4\times10^8)}{6\times10^{24} + 7\times10^{22}}$$

$$\boxed{r_{cm} = 4.61 \times 10^6 \text{ m}}$$

Since $R_E = 6.4 \times 10^6$ m, the cm of the earth-moon system is inside the earth

Problem P.47



$\vec{P}_{i1} = \langle -10, 20, -5 \rangle$ kg $\frac{m}{s}$

$\vec{P}_{i2} = \langle 8, -6, 12 \rangle$ kg $\frac{m}{s}$

$\vec{P}_c = \vec{P}_{i1} + \vec{P}_{i2} = \langle -10, 20, -5 \rangle + \langle 8, -6, 12 \rangle$

$\boxed{\vec{P}_i = \langle -2, 14, 77 \rangle \frac{kg}{ms}} = \vec{P}_f$ since $\vec{P}_c = \vec{P}_f$

Problem P55

$m_1 = 9$ kg, $\vec{v}_{i1} = \langle 4100, -2600, 2800 \rangle \frac{m}{s}$

$m_2 = 6$ kg, $\vec{v}_{i2} = \langle -450, 1800, 3500 \rangle \frac{m}{s}$

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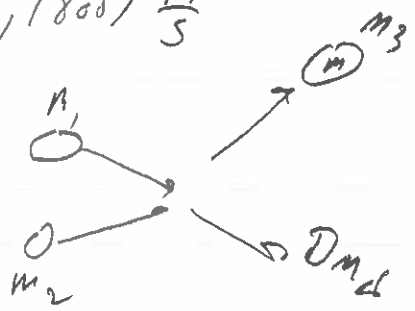
Problem P55 (cont'd)

$m_3 = 7\,kg \qquad \vec{v}_{f1} = \langle 1300, 200, 1800 \rangle \frac{m}{s}$

$m_4 = 8\,kg \qquad \vec{v}_{f2} = ?$



mass is conserved

$m_1 + m_2 = m_3 + m_4$

$9 + 6 = 15 = 7 + 8$ ✓

Use momentum conservation

$$m_1 \vec{v}_{i1} + m_2 \vec{v}_{i2} = m_3 \vec{v}_{f1} + m_4 \vec{v}_{f4}$$

$$\vec{v}_{f4} = \frac{m_1 \vec{v}_{i1} + m_2 \vec{v}_{i2} - m_3 \vec{v}_{f1}}{m_4}$$

$$= \frac{9\langle 4100, -2600, 2900 \rangle + 6\langle -450, 1800, 3500 \rangle - 7\langle 1300, 200, 1800 \rangle}{8}$$

$$\boxed{\vec{v}_{f4} = \langle 3140, -1750, 4200 \rangle \frac{m}{s}}$$