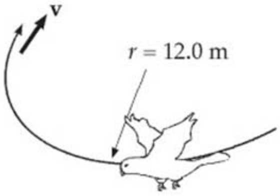
General Physics I, Midterm Exam 1 solution

1. **(a) The hawk′s centripetal acceleration is**

$$a_c = \frac{v^2}{r} = \frac{(4.00\ \text{m/s})^2}{12.0\ \text{m}} = \boxed{1.33\ \text{m/s}^2}$$

(b) The magnitude of the acceleration vector is



$$a = \sqrt{a_c^2 + a_t^2}$$

$$= \sqrt{(1.33\ \text{m/s}^2)^2 + (1.20\ \text{m/s}^2)^2} = \boxed{1.79\ \text{m/s}^2}$$

at an angle

$$\theta = \tan^{-1}\left(\frac{a_c}{a_t}\right) = \tan^{-1}\left(\frac{1.33\ \text{m/s}^2}{1.20\ \text{m/s}^2}\right) = \boxed{48.0°\ \text{inward}}$$

2.
This problem is from Page 201 (Example 7.9) of text book.
(a) The separation of two atoms is where the potential is in its minimum. To find the minimum, we set $\frac{dU(x)}{dx} = 4\varepsilon \frac{d}{dx}\left[(\frac{\sigma}{x})^{12} - (\frac{\sigma}{x})^6\right] = 4\varepsilon\left[\frac{-12\sigma^{12}}{x^{13}} + \frac{6\sigma^6}{x^7}\right] = 0$

$$\frac{dU(x)}{dx} = 4\varepsilon \frac{d}{dx}\left[(\frac{\sigma}{x})^{12} - (\frac{\sigma}{x})^6\right] = 4\varepsilon\left[\frac{-12\sigma^{12}}{x^{13}} + \frac{6\sigma^6}{x^7}\right] = 0,\quad x = (2)^{\frac{1}{6}}\sigma$$

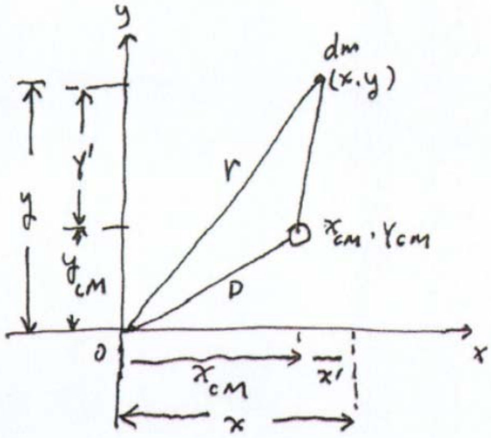
(b) Plug in numbers given, $x=2.95\times10^{-10}$ m
(c) The potential energy curve is shown in page 189 of the text book.
(d) When $x= 4.5\times10^{-10}$ m, the two atoms are subject to a restoration form to bring them together to the equilibrium point ($x=2.95\times10^{-10}$ m)
(e) This can be proved by taking the first derivative of the potential, $\frac{dU}{dx}>0$, this is the force of the two atoms at that point, so it is a restoration force to bring them together.

3.

Parallel axis theorem

P10-7

$$I = I_{cm} + MD^2$$



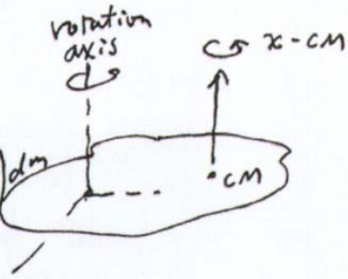
$$I = \int r^2 dm$$

$$= \int (x^2 + y^2)\, dm$$

But $x = x' + x_{cm}$

$y = y' + y_{cm}$

$$\therefore I = \int \left[(x' + x_{cm})^2 + (y' + y_{cm})^2 \right] dm$$



$$= \int (x'^2 + 2x'x_{cm} + x_{cm}^2 + y'^2 + 2y'y_{cm} + y_{cm}^2)\, dm$$

$$= \underbrace{\int (x'^2 + y'^2)\, dm}_{I_{cm}} + \underbrace{2x_{cm}\int x'\, dm}_{=0} + \underbrace{2y_{cm}\int y'\, dm}_{=0} + \underbrace{(x_{cm}^2 + y_{cm}^2)\int dm}_{D^2 M}$$

definition of center of mass

$$\therefore I = I_{cm} + MD^2$$

— Parallel axis theorem

4.

1) Perfect inelastic collision

$$m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f$$

$$v_f = \frac{m_1 v_{1i} + m_2 v_{2i}}{m_1 + m_2}$$

5.

r

$$W_{\text{on book}} = (m\vec{g}) \cdot \Delta \vec{r}$$

$$= (-mg\hat{j}) \cdot [(y_b - y_a)\hat{j}]$$

a

$$= mgy_b - mgy_a$$

$$= \Delta E_K$$

$$= \Delta K_{book}$$

$$mgy_b - mgy_a = -(mgy_a - mgy_b)$$

$$= -(U_f - U_i)$$

$$= -\Delta U_g$$

$$\therefore \ \Delta K = -\Delta U_g$$

$$\Delta K + \Delta U_g = 0$$