5-1 $\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{6.63\times10^{-34}\ \text{Js}}{1.67\times10^{-27}\ \text{kg}}\left(10^{6}\ \text{m/s}\right) = 3.97\times10^{-13}\ \text{m}$

5-3 $\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{6.63\times10^{-34}\ \text{Js}}{74\ \text{kg}}(5\ \text{m/s}) = 1.79\times10^{-36}\ \text{m}$

5-4 Taking $\lambda = 0.1\ \text{nm}$ and using $p = \frac{h}{\lambda} = mv$, we get

$$v = \frac{h}{m\lambda} = \frac{6.63\times10^{-34}\ \text{Js}}{9.11\times10^{-31}\ \text{kg}}\left(0.1\times10^{-9}\ \text{m}\right) = 7.28\times10^{6}\ \text{m/s}.$$

As $v \ll c$, it is okay to use $p = mv$ instead of $p = \gamma mv$.

5-10 As $\lambda = 2a_0 = 2(0.052\,9)\ \text{nm} = 0.105\,8\ \text{nm}$ the energy of the electron is nonrelativistic, so we can use

$$p = \frac{h}{\lambda} \text{ with } K = \frac{p^2}{2m};$$

$$K = \frac{h^2}{2m\lambda^2} = \frac{\left(6.626\times10^{-34}\ \text{J}\cdot\text{s}\right)^2}{2\left(9.11\times10^{-31}\ \text{kg}\right)\left(1.058\times10^{-10}\ \text{m}\right)^2} = 21.5\times10^{-18}\ \text{J} = 134\ \text{eV}$$

This is about ten times as large as the ground-state energy of hydrogen, which is 13.6 eV.

5-18 $\Delta x\Delta p \ge \frac{\hbar}{2}$ where $\Delta p = m\Delta v = (0.05\ \text{kg})\left(10^{-3}\times30\ \text{m/s}\right) = 1.5\times10^{-3}\ \text{kg}\cdot\text{m/s}$. Therefore,

$$\Delta x = \frac{\hbar}{2\Delta p} = \frac{6.626\times10^{-34}\ \text{J}\cdot\text{s}}{4\pi\left(1.5\times10^{-3}\ \text{kg}\cdot\text{m/s}\right)} = 3.51\times10^{-32}\ \text{m}.$$

5-23 (a) $\Delta p\Delta x = m\Delta v\Delta x \ge \frac{\hbar}{2}$

$$\Delta v \ge \frac{h}{4\pi m\Delta x} = \frac{2\pi\ \text{J}\cdot\text{s}}{4\pi(2\ \text{kg})(1\ \text{m})} = 0.25\ \text{m/s}$$

(b) The duck might move by $(0.25\ \text{m/s})(5\ \text{s}) = 1.25\ \text{m}$. With original position uncertainty of 1m, we can think of Δx growing to $1\ \text{m} + 1.25\ \text{m} = 2.25\ \text{m}$.

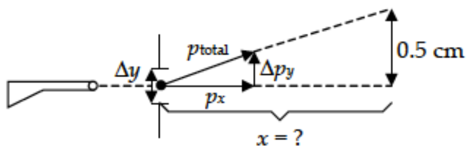
5-28 (a) $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}\ \text{J}\cdot\text{s}}{\left(1.67\times10^{-27}\ \text{kg}\right)(0.4\ \text{m/s})} = 9.93\times10^{-7}\ \text{m}$

(b) $\sin\theta = \frac{\lambda}{2D} = \frac{9.93\times10^{-7}\ \text{m}}{2\left(1.0\times10^{-3}\ \text{m}\right)} = 4.96\times10^{-4}$

As $\theta \simeq \sin\theta$, $y \simeq R\Theta = (10\ \text{m})\left(4.96\times10^{-4}\right) = 4.96\ \text{mm}$.

(c) We cannot say the neutron passed through one slit. We can only say it passed through the slits.

5-31



$\Delta y \Delta p_y \sim \hbar \quad \Delta p_y = \dfrac{\hbar}{\Delta y}$. From the diagram, because the momentum triangle and space triangle are similar, $\dfrac{\Delta p_y}{p_x} = \dfrac{0.5\text{ cm}}{x}$;

$$x = \frac{(0.5\text{ cm})p_x}{\Delta p_y} = \frac{(0.5\text{ cm})p_x \Delta y}{\hbar} = \frac{\left(0.5\times10^{-2}\text{ m}\right)(0.001\text{ kg})(100\text{ m/s})\left(2\times10^{-3}\text{ m}\right)}{1.05\times10^{-34}\text{ J}\cdot\text{s}}$$
$$= 9.5\times10^{27}\text{ m}$$

Once again we see that the uncertainty relation has no observable consequences for macroscopic systems.

5-34 (a) $g(\omega) = (2\pi)^{-1/2}\int_{-\infty}^{\infty} V(t)(\cos\omega t - i\sin\omega t)\,dt$, $V(t)\sin\omega t$ is an odd function so this integral vanishes leaving $g(\omega) = 2(2\pi)^{-1/2}\int_0^{\tau} V_0 \cos\omega t\,dt = \left(\dfrac{2}{\pi}\right)^{1/2} V_0 \dfrac{\sin\omega\tau}{\omega}$. A sketch of $g(\omega)$ is given below.