HW 10/11

4.43) $\Delta x \Delta p \geq \frac{\hbar}{2}$

$\Delta x \cdot m \Delta v \geq \frac{\hbar}{2}$

$\Delta v \geq \frac{\hbar}{2m\Delta x} \rightarrow \Delta v \geq \frac{1.055 \cdot 10^{-34}\ J \cdot s}{2(1.67 \cdot 10^{-27}\ kg)(5 \cdot 10^{-15}\ m)}$

$\boxed{\Delta v \geq 6.3 \cdot 10^{6}\ m/s}$

4.45) a) $\Delta x \Delta p \geq \frac{\hbar}{2}$

$\Delta x \geq \frac{h}{2\Delta p} \rightarrow \Delta x \geq \frac{1.055 \cdot 10^{-34}\ Js}{2(65\ kg)\left(\frac{10^{-6}\ m}{3600\ s}\right)}$

$\Delta x \geq 2.9 \cdot 10^{-27}\ m$

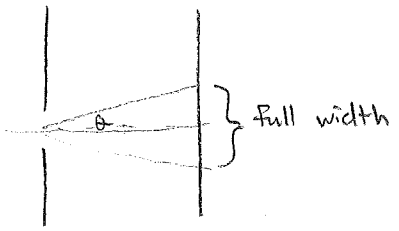
$\rightarrow \frac{\Delta x}{x} = \frac{2.9 \cdot 10^{-27}\ m}{0.25\ m} \approx$ $\boxed{10^{-26}\text{ times his width}}$

b) No, it is not sensible

4.47) $\Delta E \Delta t \geq \frac{\hbar}{2}$

$\Delta E \geq \frac{\hbar}{2\Delta t} \rightarrow \Delta E \geq \frac{1.055 \cdot 10^{-34}\ Js}{2(10^{-9}\ s)}$

$\boxed{\Delta E \geq 5.3 \cdot 10^{-26}\ J}$



4.49) a) Diffraction minima occur at $m\lambda = D\sin\theta \rightarrow \theta = \sin^{-1}\left(\frac{\lambda}{D}\right)$ for $m=1$.
The full width is then $\Delta\theta = 2\sin^{-1}\left(\frac{\lambda}{D}\right)$

electron: $\lambda = \frac{h}{p} = \frac{6.63\cdot10^{-34}\ Js}{(9.11\cdot10^{-31}\ kg)(50\ m/s)} = 1.46\cdot10^{-5}\ m$

$$\Delta\theta = 2\sin^{-1}\left(\frac{1.46\cdot10^{-5}}{0.1}\right) = \boxed{0.0167^\circ}$$

b) baseball: $\lambda = \frac{h}{p} = \frac{6.63\cdot10^{-34}\ Js}{(0.145\ kg)(50\ m/s)} = 9.14\cdot10^{-35}\ m$

$$\Delta\theta = 2\sin^{-1}\left(\frac{9.14\cdot10^{-35}}{0.1}\right) = \boxed{1.05\cdot10^{-31\ \circ}}$$

↳ If you stood on the moon, the pattern would be spread out to about 10^{-24} m on Earth. ie very small angle.

c) If the motion is in the x-direction and the slit is along the y-direction, the experiment establishes an uncertainty of $\Delta y \sim 10cm$. Thus, there is an uncertainty in p_y.
For $\Delta y \sim 10cm$, $\Delta p_y \geq 5.3\cdot10^{-34}\ kg\,m/s$ for both objects. For the electron, $p_x = (9.11\cdot10^{-31}\ kg)(50\ m/s) = 4.6\cdot10^{-29}\ kg\,m/s$.
For the baseball, $p_x = (0.145\ kg)(50\ m/s) = 7.25\ kg\,m/s$.
Thus, for the electron $\frac{\Delta p_y}{p} = \frac{\Delta p_y}{\sqrt{p_x^2 + p_y^2}} = 1.16\cdot10^{-5}$

and for the baseball, $\frac{\Delta p_y}{p} = \frac{\Delta p_y}{\sqrt{p_x^2 + p_y^2}} = 7.3\cdot10^{-35}$