2. $m\lambda = d\sin\theta \rightarrow m\lambda = d\sin 35° = 0.574\,d$. $\lambda/d = 0.574/m$. "Only" $\Rightarrow m=1$. So $\lambda/d =$ **0.574**

3. $\lambda = h/p = h/mc = 6.63\times10^{-28}\text{kg·m/s}/(9.11\times10^{-31}\text{kg})(3\times10^{8}\text{m/s}) =$ **2.43×10^{-12}m**.

4. $qV = \frac{1}{2}mu^2 = \frac{(mu)^2}{2m} = \frac{p^2}{2m} = \frac{(h/\lambda)^2}{2m}$. Solve: $\lambda = \frac{h}{\sqrt{2mqV}}$

5. $p = h/\lambda = \frac{6.63\times10^{-34}\text{J·s}}{10^{-6}\text{m}} = 6.63\times10^{-28}\text{kg·m/s}$. $u = \frac{p}{m} = \frac{6.63\times10^{-28}\text{kg·m/s}}{9.11\times10^{-31}\text{m/s}} =$ **728m/s**.
This is actually quite slow as free–electron speeds go.

8. $KE = \frac{p^2}{2m} \rightarrow 1.6\times10^{-13}\text{J} = \frac{p^2}{2(1.67\times10^{-27}\text{kg})} \Rightarrow p = 2.31\times10^{-20}\text{kg·m/s}$.
$\frac{6.63\times10^{-34}\text{J·s}}{2.31\times10^{-20}\text{kg·m/s}} =$ **2.87×10^{-14}m**. $20\times1.6\times10^{-19}\text{J} = \frac{p^2}{2(1.67\times10^{-27}\text{kg})}$
$\Rightarrow p = 1.03\times10^{-22}\text{kg·m/s}$. $\frac{6.63\times10^{-34}\text{J·s}}{1.03\times10^{-22}\text{kg·m/s}} =$ **6.41×10^{-12}m**.

10. $p = h/\lambda = \frac{6.63\times10^{-34}\text{J·s}}{10^{-9}\text{m}} = 6.63\times10^{-25}\text{kg·m/s}$. $u = \frac{p}{m} = \frac{6.63\times10^{-25}\text{kg·m/s}}{9.11\times10^{-31}\text{m/s}} =$ **7.28×10^{5}m/s**.
(b) Using result of exercise 4, $\lambda = \frac{h}{\sqrt{2mqV}} \rightarrow 10^{-9}\text{m} = \frac{6.63\times10^{-34}\text{J·s}}{\sqrt{2(9.11\times10^{-31}\text{kg})(1.6\times10^{-19}\text{C})V}}$
$\Rightarrow V =$ **1.5V**. In practice it is much higher than this, giving a smaller λ and better resolution.

11. $m\lambda = d\sin\theta$. Using result of exercise 4, $\lambda = \frac{h}{\sqrt{2mqV}} = \frac{6.63\times10^{-34}\text{J·s}}{\sqrt{2(9.11\times10^{-31}\text{kg})(1.6\times10^{-19}\text{C})(54\text{V})}} =$
$1.67\times10^{-10}\text{m}$. $1\,(1.67\times10^{-10}\text{m}) = d\sin 50° \Rightarrow d =$ **2.2×10^{-10}m**.

12. To find moon's speed, use F = ma. The gravitational force gives it centripetal acceleration:
$G\frac{m_{earth}m_{moon}}{r^2} = m_{moon}\frac{v^2}{r} \Rightarrow v = \sqrt{\frac{G\,m_{earth}}{r}} = \sqrt{\frac{(6.67\times10^{-11}\text{N·m}^2/\text{kg}^2)(5.98\times10^{24}\text{kg})}{3.84\times10^{8}\text{m}}} =$
$1.02\times10^{3}\text{m/s}$. Thus $\lambda = h/p = \frac{6.63\times10^{-34}\text{J·s}}{(7.35\times10^{22}\text{kg})(1.02\times10^{3}\text{m/s})} = 8.85\times10^{-60}\text{m}$.
This is much smaller than the dimensions of the region in which it moves. In fact, as in the airplane's case in example 3.1, it is smaller than the atomic nucleus! The moon certainly **orbits as a classical particle**.

23. $\Delta x\,\Delta p \geq \frac{1}{2}\hbar \rightarrow (10^{-6}\text{m})(0.145\text{kg})\,\Delta v \geq \frac{1}{2}(1.055\times10^{-34}\text{J·s}) \Rightarrow \Delta v \geq$ **3.6×10^{-28}m/s**. $\frac{1\text{nm}}{\text{billion centuries}}$

25. $\Delta x\,\Delta p \geq \frac{1}{2}\hbar \rightarrow (5\times10^{-15}\text{m})(1.67\times10^{-27}\text{kg})\,\Delta v \geq \frac{1}{2}(1.055\times10^{-34}\text{J·s}) \Rightarrow \Delta v \geq$ **6.3×10^{6}m/s**.
Its KE would be $\frac{1}{2}(1.67\times10^{-27}\text{kg})(6.3\times10^{6}\text{m/s})^2 \cong 0.2\text{MeV}$, on the low side of typical energies in the nucleus.

28. $\Delta x\,\Delta(mv) \geq \frac{1}{2}\hbar \rightarrow \Delta v \geq \frac{\hbar}{2m\Delta x} = \frac{\hbar}{2mL}$. The KE ~ $\frac{1}{2}m(\Delta v)^2 \geq$ $\mathbf{\frac{\hbar^2}{8mL^2}}$

30. $\theta_{wave} \cong \sin\theta_1 = \frac{1\lambda}{a} = \frac{h/(m\,v)}{a} = \frac{h}{m\,v\,a}$. $\theta_{part.} = \frac{\Delta p_y}{p} \cong \frac{\frac{1}{2}\hbar/\Delta y}{p} = \frac{\frac{1}{2}\hbar/a}{mv} = \frac{h}{4\pi m v a}$. $\frac{\theta_{wave}}{\theta_{part.}} = 4\pi$

49. $(\gamma_u - 1)mc^2 = mc^2 \Rightarrow \gamma_u = 2 \Rightarrow u = (\sqrt{3}/2)\,c$. $p = \gamma_u m u = 2\,(1.67\times10^{-27}\text{kg})(\sqrt{3}/2)\,c$
$= 8.68\times10^{-19}\text{kg·m/s}$. $\lambda = h/p = \frac{6.63\times10^{-34}\text{J·s}}{8.68\times10^{-19}\text{kg·m/s}} =$ **7.64×10^{-16}m**. This is smaller than the proton's accepted approximate radius. Such a fast proton would certainly behave as a **particle**.