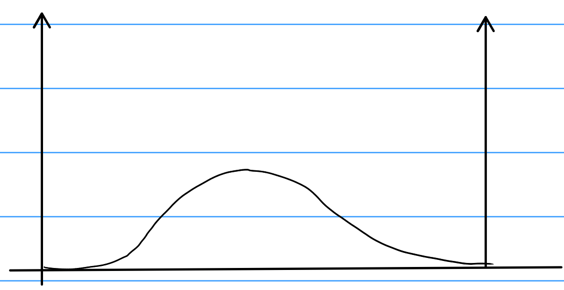
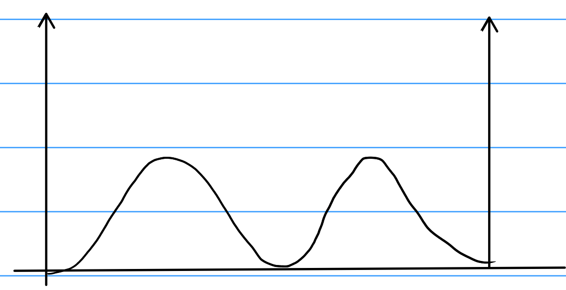
1) The wave function, Ψ, is related to the probability that a particle will be found in a particular location at a particular time. Specifically $|\Psi|^2$ is the probability density at the particle's location at a particular time.

2) A particle represented by a plane wave has an equal probability at being anywhere and the probability can't be normalized because the integral over all space doesn't converge.

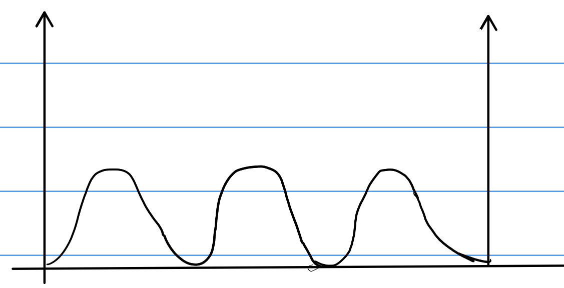
3) a)



b)



c)



4)

	bacterium	virus	He	nucleus
K	16.7 yeV	41.8 zeV	854 aeV	669 feV
Δx	180 nm	15.9 nm	111 pm	3.98 pm

$$\lambda = \frac{h}{p}$$

$$p = \sqrt{2Km}$$

$$\lambda^2 = \frac{h^2}{2Km}$$

$$K = \frac{h^2}{2m\lambda^2}$$

5) a) $\Delta x = \sqrt{\langle (x - \langle x \rangle)^2 \rangle}$

b) $\Delta x \Delta p = \frac{\hbar}{2}$

$\Delta p = \frac{\hbar}{2\Delta x}$

$= \frac{\hbar}{r}$

c) $E = K + U = \frac{p^2}{2m} - \frac{ke^2}{r}$

6) $\lambda = 18\,\mathring{A}$

a) $pc = \frac{hc}{\lambda}$

$= 689\ eV$

$p = 689\ eV/c$

$p = mv$

$v = \frac{689\ eV/c}{9.396 \times 10^8\ eV/c^2}$

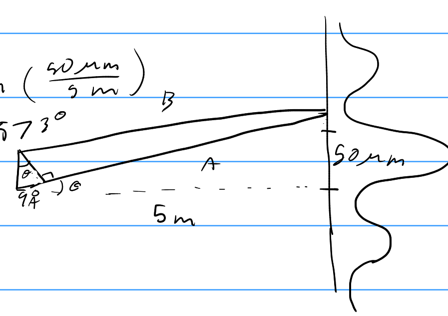
$= 7.33 \times 10^{-7} c$

b) $d_p \approx 50\ \mu m$

c) $d_p = 50\ \mu m$

$\theta_2 = \operatorname{atan}\left(\frac{50\ \mu m}{5\ m}\right)$

$= 0.000573°$



$D \sin\theta = \frac{\lambda}{2} = 9\,\mathring{A}$

$D = \frac{\lambda}{2 \sin 2\theta}$

$= \frac{9\,\mathring{A}}{\sin\theta}$

$= 90\ \mu m$

7) a) $\Delta E \Delta t \approx \frac{\hbar}{2}$

$\Delta E = 92.9 \text{ keV}$

$\Delta t = 7.61 \times 10^{-16} s$

b) $E = 5 \text{ GeV}$

$(5 \text{ GeV})^2 = p^2c^2 + m_0^2 c^4$

$pc = \sqrt{-(3096.900 \text{ MeV})^2 + 25 \text{ GeV}^2}$

$p = 3.93 \text{ GeV}/c$

$\lambda = \frac{hc}{pc}$

$= 3.16 \times 10^{-16} m$

c) $p = \gamma m_0 v$

$= \frac{m_0 v}{\sqrt{1 - \frac{v^2}{c^2}}}$

$p\sqrt{1-v^2/c^2} = m_0 v$

$p^2\left(1 - \frac{v^2}{c^2}\right) = m_0^2 v^2$

$p^2 = m_0^2 v^2 + p^2 \frac{v^2}{c^2}$

$= v^2\left(m_0^2 + \frac{p^2}{c^2}\right)$

$v = \sqrt{\frac{p^2}{m_0^2 + \frac{p^2}{c^2}}}$

$= 0.785 c$

$t' = \frac{\Delta t}{\sqrt{1 - 0.785^2}}$

$= 1.228 \times 10^{-15} s$

$d = vt'$

$= 2.89 \times 10^{-7} m$