

①

②

$$1) \quad v = \frac{99}{100}$$



$$\text{Lab} \quad x=0 \\ t=0$$

$$x = 0,5 \text{ m}$$

$$a) \quad t = \frac{x}{v} = \frac{100 \times 0,5}{99} = 0,505 \text{ m}$$

$$b) \quad \Delta^2 = t^2 - x^2 = 0,505^2 - 0,5^2 = 0,255 - 0,25 = 5 \times 10^{-3} \text{ m}$$

$$c) \quad \Delta' = \Delta = 5 \times 10^{-3} \text{ m}$$

$$d) \quad \begin{cases} \Delta' = \Delta \\ x' = 0 \end{cases} \Rightarrow t' = \Delta' = \Delta = 5 \times 10^{-3} \text{ m} = \frac{5 \times 10^{-3}}{3 \times 10^8} = 1,67 \times 10^{-11} \text{ s}$$

e) O resultado era o mesmo.

2)

$$E = 2 \text{ GeV}$$

$$m = 938 \text{ MeV}$$

$$\begin{matrix} \text{---} & \text{---} \\ E & m \end{matrix}$$

$$a) \quad E_t = E + m = 2,938 \text{ GeV}$$

$$b) \quad P_t = 2 \text{ GeV}$$

$$c) \quad \text{Antes} \quad (E + m, E)$$

$$\text{Depois} \quad (E' + E_p, -E' + P_p)$$

$$\left\{ \begin{array}{l} E + m = E' + E_p \\ E = -E' + P_p \\ m^2 = E_p^2 - P_p^2 \end{array} \right. \quad \left\{ \begin{array}{l} 2E + m = E_p + P_p \\ P_p = 2E + m - E_p \\ m^2 = E_p^2 - (-E_p + 2E + m)^2 \end{array} \right.$$

$$m^2 = E_p^2 - E_p^2 - 4E^2 - m^2 + 4EE_p + 2mE_p + 4Em$$

$$(4E + 2m) E_p = 2m^2 + 4E^2 - 4Em$$

$$E_p = \frac{m^2 + 2E^2 - 2Em}{2E + m} = \frac{0,938^2 + 2 \times 4 - 4 \times 0,938}{4 + 0,938} = \frac{5,128}{4,938} = 1,038 \text{ GeV}$$

$$P_p = 2E + m - E_p = 4 + 0,938 - 1,038 = 3,9 \text{ GeV}$$

$$E' = E + P_p = 2 + 3,9 = 5,9 \text{ GeV}$$

$$3) \quad |\psi\rangle = \frac{\sqrt{3}}{2} |0\rangle + \frac{1}{2} |1\rangle$$

$$a) \quad P_0 = \left| \frac{\sqrt{3}}{2} \right|^2 = \frac{3}{4}$$

$$b) \quad |\psi'\rangle = |0\rangle$$

$$c) \quad H|0\rangle = \frac{1}{\sqrt{2}} (|0\rangle + |1\rangle)$$

$$H|1\rangle = \frac{1}{\sqrt{2}} (|0\rangle - |1\rangle)$$

$$H|\psi\rangle = \frac{\sqrt{3}}{2} H|0\rangle + \frac{1}{2} H|1\rangle =$$

$$= \frac{\sqrt{3}}{2} \cdot \frac{1}{\sqrt{2}} (|0\rangle + |1\rangle) + \frac{1}{2} \frac{1}{\sqrt{2}} (|0\rangle - |1\rangle) =$$

$$= \frac{\sqrt{3}+1}{2\sqrt{2}} |0\rangle + \frac{\sqrt{3}-1}{2\sqrt{2}} |1\rangle$$

$$4) \lambda = 550 \text{ nm} = 550 \times 10^{-9} \text{ m}$$

$$a) f = \frac{c}{\lambda} = \frac{3 \times 10^8}{550 \times 10^{-9}} = 5,45 \times 10^{14} \text{ Hz}$$

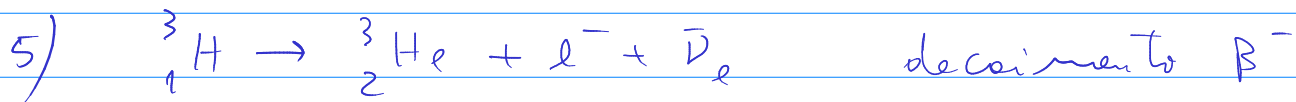
$$T = \frac{1}{f} = 1,83 \times 10^{-15} \text{ s}$$

$$\omega = 2\pi f = 3,43 \times 10^{15} \text{ rad/s}$$

$$k = \frac{2\pi}{\lambda} = \frac{2\pi}{550 \times 10^{-9}} = 1,14 \times 10^7 \text{ rad/m}$$

$$b) p = \hbar k = \frac{h}{2\pi} k = \frac{h}{\lambda} = 1,2 \times 10^{-27} \text{ kg m/s}$$

$$E = \hbar \omega = h f = 3,6 \times 10^{-19} \text{ J}$$



6) São dois quarks u e um d
up down

7) Interações fracas.