PHY2361 Midterm test - solutions 2021

**1.** a) $t' = \dfrac{d}{v} = \dfrac{d}{4c/5} = \dfrac{5d}{4c}$

2

b) $x = \gamma(x' + vt')$ where $v = \frac{3}{5}c$ of rocket (S') wrt earth (S)

2-$\gamma$ $= \frac{5}{4}\left(d + \frac{3c}{5}\cdot\frac{5d}{4c}\right)$ $\qquad \gamma = (1 - v^2/c^2)^{-1/2} = (1-(3/5)^2)^{-1/2}$

$= (16/25)^{-1/2} = \frac{5}{4}$

2-$x$ $= \frac{5}{4}\left(1 + \frac{3}{4}\right)d = \frac{35}{16}d$

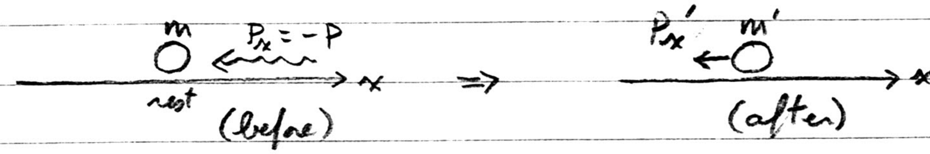
2-$t$ $t = \gamma(t' + vx'/c^2) = \frac{5}{4}\left(\frac{5d}{4c} + \frac{3c}{5}\cdot d/c^2\right) = \frac{5}{4}\underbrace{\left(\frac{5}{4} + \frac{3}{5}\right)}_{\frac{25+12}{20}}\frac{d}{c} = \underbrace{\frac{37}{16}}_{2.3125}\frac{d}{c}$

/6

c) $d_s = \gamma^{-1}d$ by length contraction

2 $= \frac{4}{5}d$

**2.**




2 Cons. of $P_x$: $\underset{(\text{after})}{P_x'} = \underset{(\text{before})}{P_x} = \underset{(\text{atom})}{0} + \underset{(\text{photon})}{(-p)} = -p \quad (1)$

2 Cons. of E: $\underset{(\text{atom after})}{E'} = \underbrace{\underset{(\text{atom})}{E_0} + \underset{(\text{photon})}{pc}}_{\text{before}}$

1 $= mc^2 + pc \qquad (2)$

for atom after:

1 $E'^2 = E_0'^2 + p_x'^2c^2$

1 $\overset{(2)}{(mc^2 + pc)^2} = (m'c^2)^2 + \overset{(1)}{(-p)^2}c^2$

1 $(mc^2)^2 + 2mc^2\cdot pc + \cancel{(pc)^2} = (m'c^2)^2 + \cancel{p^2c^2}$

2 $m'^2 = m^2 + 2mp/c \Rightarrow m' = (m^2 + 2mp/c)^{1/2}$

3. a) - quantized energy of photon $E = hf = hc/\lambda$ is absorbed
by electron (i.e. $\Delta E_{electron} = hf$) 2

- explains dependence of ejected electron's K.E. max. (i.e. the
stopping potential $V_s$ measured) on light frequency, and not 3
on light intensity as classical theory would have predicted.

b) - electron described by deBroglie wave 2
- diffraction of deBroglie wave from ordered rows of atoms in crystal
predicts specific directions of elastically scattered
electrons, that was not predicted classically. 3
- this supports $\lambda = h/p$ for electron

4. a) $hf = E_6 - E_5$ where $E_n = -E_0/n^2$ and $E_0 = 13.6\,eV$ 1

$$\therefore f = -\frac{E_0}{h}\left(\frac{1}{6^2} - \frac{1}{5^2}\right)$$ 1

$$= -\underbrace{\frac{13.6\,eV \cdot 1.6 \cdot 10^{-19}\,J/eV}{6.63 \cdot 10^{-34}\,Js}}_{3.28 \cdot 10^{15}\,Hz}\underbrace{\left(\frac{1}{36} - \frac{1}{25}\right)}_{.0122} = 4.01 \cdot 10^{13}\,Hz$$ 3

1 b) $r_n = n^2 a_0$ and $n\hbar = L_n = m v_n r_n \Rightarrow v_n = n\hbar/m r_n$

1 $$\therefore f_n = T_n^{-1} = (2\pi r_n / v_n)^{-1} = \frac{n\hbar}{m r_n} / 2\pi r_n = \frac{n\hbar}{2\pi m r_n^2}$$

2 $$= \frac{6(1.055 \cdot 10^{-34}\,Js)}{2\pi(9.11 \cdot 10^{-31}\,kg)(1.90 \cdot 10^{-9}\,m)^2}$$ $r_6 = 6^2 a_0 = 6^2(0.529 \cdot 10^{-10}\,m) = 1.90 \cdot 10^{-9}\,m$

1 $$= 3.05 \cdot 10^{13}\,Hz$$