Fall 2022 Exam I Phys-222

1) $C = 3E8\left(\frac{m}{s}\right) = 3E5\left(\frac{km}{s}\right)$

$1\,ly = 1y \cdot C \Rightarrow [3.15E7(s)][3E5(\frac{km}{s})] = \underline{9.46E12(km)}$

$1y = \frac{365\,d}{} \Big| \frac{24\,h}{1\,d} \Big| \frac{3600\,s}{1\,h} = 3.15E7(s)$

$\rightarrow 15\,ly = \boxed{1.4\,E14(km)}$

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2) Newton's law hold best for inertial reference frames.

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3) $l' = l_0 \frac{1}{\gamma} \Rightarrow \frac{l'}{l_0} = \frac{1}{\gamma}$ $\gamma = \frac{1}{\sqrt{1-\beta^2}}$

$\frac{l'}{l_0} = 0.99 = \frac{1}{\gamma} = \sqrt{1-\beta^2}$

$\Rightarrow (0.99)^2 = 1 - \beta^2 \Rightarrow \beta^2 = 1-(.99)^2 \Rightarrow \beta = \sqrt{1-(0.99)^2} = 0.14$

$\boxed{V = \beta c = 0.14c}$

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4) $V = 0.14c = 4.2E4\left(\frac{km}{s}\right)$ $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \underline{1.0099}$

$C = 3E8(m/s) = 3E5\left(\frac{km}{s}\right)$

$t = \frac{d}{v} = \frac{5000(km)}{4.2E4\left(\frac{km}{s}\right)} = \underline{0.119(s)}$ $t' = t \cdot \gamma = 0.120(s)$

$\Delta t = |t' - t| = 0.00118(s) \Rightarrow \boxed{1.2\,(ms)}$

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5) Galilean invariance means all of the choices given,

6)

$$1 \text{ trillion} = \underbrace{1\,000\,000\,000\,000}_{12 \text{ zero's}} = \boxed{10^{12}}$$

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7) The M & M experiment showed that light did not behave as one would expect if the Ether existed. This forced people to reconsider the existance of the Ether & how light behaved.

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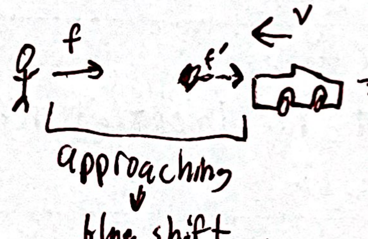
8) $f' = f_0 \sqrt{\frac{1+\beta}{1-\beta}}$

a)

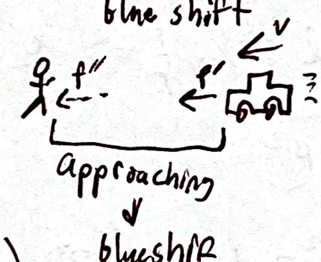


$\Delta f' = |f' - f_0|$

$\Delta f'' = |f'' - f'|$

$\rightarrow \underline{\Delta F = \Delta f' + \Delta f''}$

b)



$$\Delta f' = f_0\sqrt{\frac{1+\beta}{1-\beta}} - f_0 = \underline{f_0\left(\sqrt{\frac{1+\beta}{1-\beta}} - 1\right)}$$

$$\Delta f'' = f'\sqrt{\frac{1+\beta}{1-\beta}} - f_0\sqrt{\frac{1+\beta}{1-\beta}} = f_0\sqrt{\frac{1+\beta}{1-\beta}}\cdot\sqrt{\frac{1+\beta}{1-\beta}} - f_0\sqrt{\frac{1+\beta}{1-\beta}} = \underline{f_0\sqrt{\frac{1+\beta}{1-\beta}}\left(\sqrt{\frac{1+\beta}{1-\beta}} - 1\right)}$$

for $\beta \approx 0 \rightarrow \sqrt{\frac{1+\beta}{1-\beta}} \approx 1$

$$\approx \underline{f_0\,(1)\left(\sqrt{\frac{1+\beta}{1-\beta}} - 1\right) = \Delta f'}$$

$$\rightarrow \boxed{\Delta F = \Delta f' + \Delta f'' \approx \Delta f' + \Delta f' = 2\Delta f'}$$

In words: The light frequency is blue-shifted when traveling from the police officer to the approaching car. The light is then blue-shifted again by a <u>similar amount</u> when it returns to the police officer. The <u>total shift</u> in frequency is therefore <u>approximately doubled</u>.

9) $d_e = 4\ ly.$, $t_e = 7y$ $\quad V = \frac{d}{t} = \frac{4\ ly.}{7y} = \underline{0.57 \cdot c} \rightarrow \underline{\beta = 0.57}$

$$\boxed{\gamma = \frac{1}{\sqrt{1-\beta^2}} = \frac{1}{\sqrt{1-(0.57)^2}} = 1.22}$$

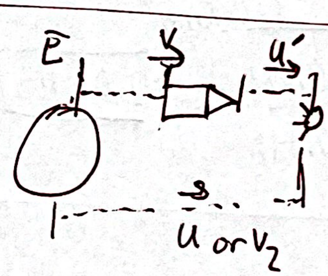
10) $t' = t \cdot \gamma$ from astronought perspetive, $t_s' = 7y$.

$$\boxed{t_a = \frac{t_e}{\gamma} = 5.74y}$$

11) $\boxed{\Delta t = (t_e - t_s) = (7 - 5.74) = 1.26y}$

12) $V_1 = 0.60c$, $u_x' = 0.90c$

$V_2 = ? = u_x$

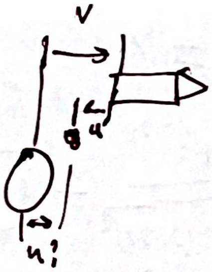


$$\boxed{u = \frac{u' + v}{1 + \frac{u' \cdot v}{c^2}} = \frac{0.9c + 0.6c}{1 + \frac{(0.6c)(0.9c)}{c^2}} = 0.97c}$$

13) $C = 3E8\left(\frac{m}{s}\right) = 3E5\left(\frac{km}{s}\right)$ $\quad V = 300000\left(\frac{km}{s}\right) = 3E5\left(\frac{km}{s}\right)$

$$\boxed{\beta = \frac{V}{c} = \frac{3E5\left(\frac{km}{s}\right)}{3E5\left(\frac{km}{s}\right)} = 1}$$

14) $V=+0.8c$, $u'=-0.7c$



$$\boxed{u=\frac{(-0.7c)+(0.8c)}{1+\frac{(-0.7\cancel{c})(0.8\cancel{c})}{\cancel{c^2}}}}=\boxed{0.23c}$$

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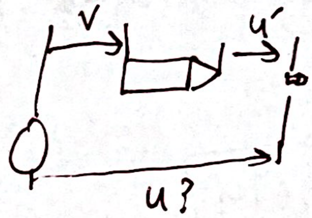
15) $V=+0.8c$, $u'=+0.7c$



$$\boxed{u=\frac{(0.7c)+(0.8c)}{1+\frac{(0.7\cancel{c})(0.8\cancel{c})}{\cancel{c^2}}}}=\boxed{0.96c}$$

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16) $f=700\ Hz$, $V=-0.84c \Rightarrow \beta=-0.84$

receding

$$\boxed{f'=(700\ Hz)\sqrt{\frac{1+(-0.84)}{1-(-0.84)}}}=\boxed{206\ Hz}$$

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17) The person using the meter stick on the spaceship is moving at the same relative velocity as the meter stick, Thus, no relative effects will be noticed & the meter stick can be used like normal (by people on the spaceship).

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18) $f_0=493.9\ THz$, $V=+0.032c \Rightarrow \beta=0.032$

approaching

$$\boxed{f'=f_0\sqrt{\frac{1+\beta}{1-\beta}}} \Rightarrow 493.9(THz)\sqrt{\frac{1+(0.032)}{1-(0.032)}}=\boxed{509.9\ (THz)}$$

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19) Classical physics does not account for either relativistic effects or quantum effects.

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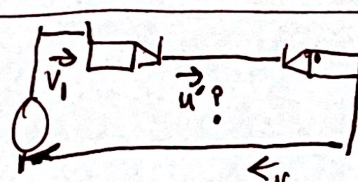
20) $V_1=0.3c$, $V_2=-0.5c$



u

$$\boxed{u'=\frac{u-v}{1-\frac{uv}{c^2}}}=\frac{(0.3c)-(-0.5c)}{1-\frac{(0.3\cancel{c})(-0.5\cancel{c})}{\cancel{c^2}}}=0.695..c=\boxed{0.7c}$$