Physics 1B Final

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Problem 1: ~~4~~

a) $\boxed{4}$

b) $\boxed{3}$

c) $\boxed{5}$

Problem 2:

$(P) \xrightarrow[V_p]{}$ $\quad$ $[T] \xrightarrow[V_T]{}$

$V_T \geq V_p$

~~$f_{reflect}$~~

$f_L = \frac{V \pm V_L}{V \pm V_S} f_s$

~~$f_{reflect} = \frac{V+V_T}{V+V_S} f_s$~~

~~$f_{reflect}$~~

$f_{reflect} = \frac{V - V_T}{V - V_p} f_p$

(signs show the truck is moving away and the police is moving towards)

$f'_p = \frac{V + V_p}{V + V_T} f_{reflect}$

a) $= \boxed{\frac{V_s + V_p}{V_s + V_T}\left(\frac{V_s - V_T}{V_s - V_p}\right) f_p}$

~~2b) $f_{beat} = \frac{V_s + V_p}{V_s + V_T}\left(\frac{V_s - V_T}{V_s + V_p}\right) - f_p$~~

~~$\frac{1+\frac{V_p}{V_s}}{1+\frac{V_T}{V_s}}\left(\frac{1-\frac{V_T}{V_s}}{1-\frac{V_p}{V_s}}\right) - f_p$~~

~~$f_{beat} =$~~

2b) $f_{beat} = |f_p' - f_p|$

$$= \left[\frac{V_s + V_p}{V_s + V_T}\left(\frac{V_s - V_T}{V_s - V_p}\right) - 1\right] f_p$$

$$= \left[\frac{1 + \frac{V_p}{V_s}}{1 + \frac{V_T}{V_s}}\left(\frac{1 - \frac{V_T}{V_s}}{1 - \frac{V_p}{V_s}}\right) - 1\right] f_p$$

~~2c)~~

$$\boxed{\left[\left(1 + \frac{V_p}{V_s}\right)\left(1 - \frac{V_T}{V_s}\right) - 1\right] f_p}$$

$= [$

If $V_p = V_T$, both vehicles are moving at the same velocity, therefore they are static relative to each other. Due to this, the sound reflected back to the police car is the same as played from the police car and there is no beat frequency.

Problem 3:

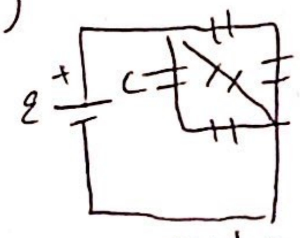
3a) $C = 2\pi\varepsilon_0 \frac{L}{\ln\left(\frac{R}{r}\right)}$

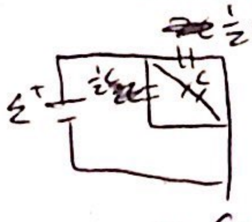
$$C = 2\pi\varepsilon_0\left(\frac{L}{\ln\left(\frac{R-(b-a)}{r}\right)}\right)$$

The conducting surface effectively reduces the outer radius (it's outside the inner radius so r is unaffected) by the distance between the conducting surface's outer radius and inner radius.

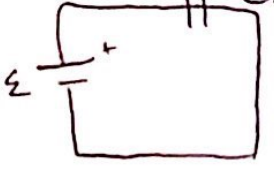
3b) ~~For the capacitance to be maximized, ... therefore the metal cylinder would effectively not exist ... shows that the larger the volume of the metal cylinder the less capacitance the capacitor has.~~

3c)





$C_{eq} = \boxed{2C}$



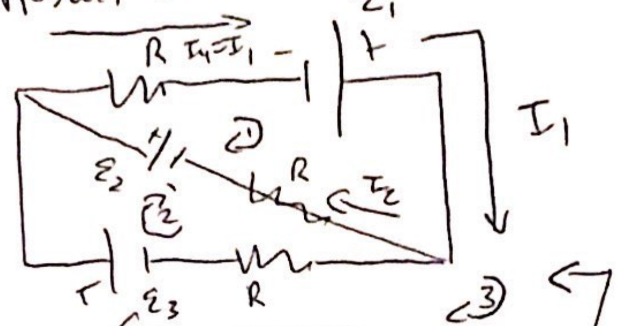
$U = \frac{1}{2}C_{eq}V^2$

$V = \mathcal{E}$

$E = \frac{1}{2}(2C)(\mathcal{E}^2) = \boxed{C\mathcal{E}^2}$

Problem 4:

4a)



$I_3 = I_1 - I_2$

entire circuit is in terms of I_1 and I_2

4b) ~~Loop 1:~~

~~$\mathcal{E}_1 = I_1R + I_2R$~~

~~Loop 2:~~

~~$\mathcal{E}_1 = I_2R + \mathcal{E}_2 + I_3R$~~

~~Loop 2~~

~~$\mathcal{E}_3 = \mathcal{E}_2 - I_2R + I_3R$~~

Loop 3:

~~$\mathcal{E}_1 + \mathcal{E}_3 = I_1R + I_2R$~~

~~Loop 2~~ Loop 1:

$$\mathcal{E}_1 - I_2R + \mathcal{E}_2 - I_1R = 0$$

Loop 2:

$$\mathcal{E}_3 - \mathcal{E}_2 + I_2R - I_3R = 0$$

Loop 3:

$$\mathcal{E}_1 - I_3R + \mathcal{E}_3 - I_1R = 0$$

4c) ~~Σ~~

$I_3 = 0A$

$\therefore$ $\mathcal{E}_3 - \mathcal{E}_2 + I_2 R = 0$

and

$\mathcal{E}_1 + \mathcal{E}_3 - I_1 R = 0$

$$\boxed{\begin{aligned} \mathcal{E}_3 &= \mathcal{E}_2 - I_2 R \\ \mathcal{E}_1 &= -\mathcal{E}_3 + I_1 R \\ \mathcal{E}_2 &= -\mathcal{E}_1 + I_2 R + I_1 R \end{aligned}} \rightarrow \boxed{\mathcal{E}_2 = \mathcal{E}_1}$$

Find I_2

$I_2 = I_1$ if $I_3 = 0A$

$\mathcal{E}_2 = -\mathcal{E}_1 + I_2 R + I_2 R$

$\mathcal{E}_2 + \mathcal{E}_1 = 2 I_2 R$

$\cancel{I_2 = \frac{2\mathcal{E}_1}{2R}} \rightarrow \frac{2\mathcal{E}_1}{2R} = \boxed{\frac{\mathcal{E}_1}{R}}$

towards upper left

3b) Capacitance is maximized when b = R and a = r, therefore the capacitance is greater when the volume of the metal cylinder is closer to the volume of the gap between the cylindrical capacitor.