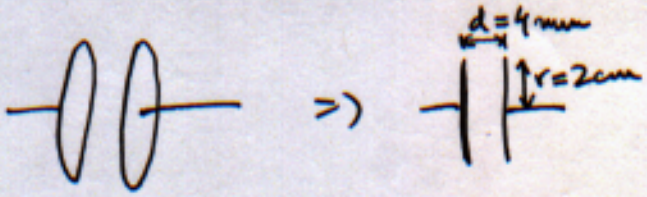
PHYS 142, EXAM 1 NAME:_____ SECTION:_____

(10) 3. Consider a parallel plate capacitor with circular plates each of radius **r**=2cm separated by a distance **d**=4mm. (a) What is the capacitance of this capacitor? (b) What happens to the capacitance if I completely fill the capacitor with plastic with a dielectric constant of 3.4? (c) What is the capacitance of the capacitor if I, instead of completely filling it with this plastic, I just put a 2mm slab of plastic on one of the plates inside the capacitor? (HINT: you can treat the new capacitor with a slab of plastic as two capacitors connected in series: one having only vacuum inside, and the other being completely filled with the plastic.)



a) $C = \frac{\varepsilon_0 A}{d} = \boxed{\frac{\varepsilon_0 \pi r^2}{d}}$ (2) correct equation

$$C = \frac{8.85\times10^{-12}\,(2^2)(10^{-2})^2\,(3.14)}{4\times10^{-3}}$$

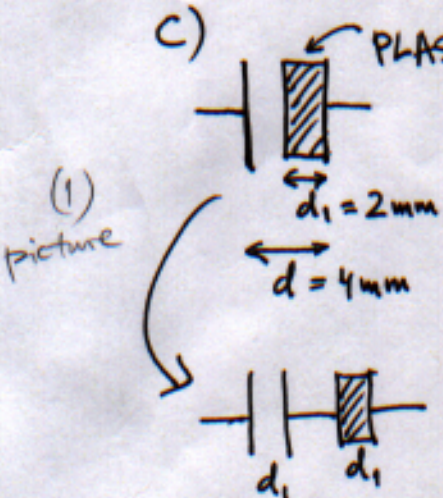
$\boxed{C = 2.78\times10^{-12}\ F}$ $= 2.78\ pF$ (1) correct value

b) it increases:

$C' = K\cdot C = 3.4\cdot 2.78$ pF

$\boxed{C' = 9.4\ pF}$ (1) correct equation or value

c)



(1) picture

total capacitance of the two in series:

$\frac{1}{C'} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{d_1}{\varepsilon_0 A} + \frac{d_1}{\varepsilon_0 A K}$ (2) in series

$\frac{1}{C'} = \frac{K d_1 + d_1}{\varepsilon_0 A K}$

$\Rightarrow \boxed{C' = \frac{\varepsilon_0 A}{d_1}\frac{K}{(K+1)}}$ (2) equation

$d_1 = d/2 \rightarrow C' = \frac{\varepsilon_0 A}{d}\frac{2K}{(K+1)}$

or $\Rightarrow \boxed{C' = C\frac{2K}{(K+1)}}$

$\Rightarrow C' = 2.78$ pF $\cdot \frac{2(3.4)}{(3.4+1)}$

value (1) $\boxed{C' = 4.3\ pF}$

$\varepsilon_0 = 8.85\times10^{-12}\ C^2/(Nm^2)$ $e = 1.6\times10^{-19}\ C$ $m_e = 9.1\times10^{-31}\ kg$