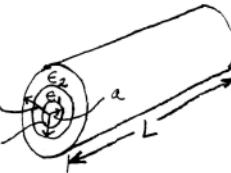


Problem 1 (25 points) Consider a long coaxial capacitor. The space between the conductors is filled with a dielectric of dielectric constant $\epsilon_r = 2 \times 10^{-11}$ Farad/m. between $r = a = 10^{-2}$ m, and $r = b = 2 \times 10^{-2}$ m, and with dielectric constant $\epsilon_2 = 4 \times 10^{-11}$ Farad/m, between $r = 2 \times 10^{-2}$ m, and $r = 3 \times 10^{-2}$ m. Find the capacitance if the length of the capacitor is $L = 0.2$ m. (Neglect fringing.)



Problem 2 (30 points) If the potential is given by $V(x, y, z) = 3 \sin \pi x$ Volts,

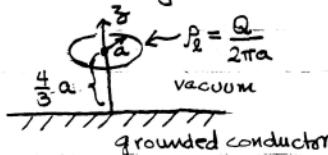
(a) what is the electric field $E(x, y, z)$?

(b) what is the volume charge density $\rho(x, y, z)$ if $\epsilon = \epsilon_0$?

(c) how much work does one have to do to move a charge of -0.3 coulombs from the point $(x = 4.25, y = 0, z = 0)$ to the point $(x = 0, y = 2.00, z = 0)$?

Problem 3 (25 points) A circular line

charge of density $\rho_L = Q/(2\pi a)$ Coulombs/meter and radius a is situated in the plane



$z = \frac{4}{3}a$ in vacuum. The region $z < 0$ is occupied by a grounded perfect conductor. What is the force on a point charge of -3Q coulombs situated at the center of the circle? Express your answer in terms of Q, a and ϵ_0 .

Problem 4 (20 points) Given a current density $J = (5t \cos \pi x) \hat{a}_x$ Amperes/meter², what is the total charge $Q(t)$ in the cube $0 \leq x \leq 1/2$ meter, $0 \leq y \leq 1/2$ meter, $0 \leq z \leq 1/2$ meter, if the total charge in the cube is zero at $t = 0$?

Problem 5 (20 points) Given a current density

$$\vec{J} = \begin{cases} 3a_z & \text{for } r < a \\ 0 & \text{for } r > a \end{cases} \quad (\text{where } r \text{ is in cylindrical coordinates}),$$

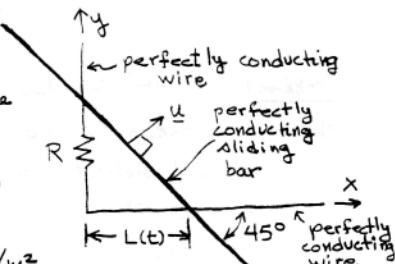
use Ampere's law to find H in $r < a$ and in $r > a$.

Problem 6

(40 points) As shown, a perfectly conducting sliding bar in electrical contact with wires on the positive x -axis and the positive y -axis is moving with a constant speed $u = 5 \text{ m./s.}$, so that $L(t) = 5\sqrt{2}t$ meters. There is a uniform magnetic field $B = 2 \text{ g}_z$ Webers/m².

At the instant that $L(t) = 1$ meter the external force exerted on the bar necessary to keep it moving at $u = 5 \text{ m./s.}$ is $F = 5 \text{ Newtons}$.

- (a) What is the magnetic flux $\Phi(t)$ through the triangular region bounded by the bar and the x and y axes?
- (b) What is the voltage across the resistor at the instant of time when $L(t) = 1$ meter?
- (c) What is the current when $L(t) = 1$ meter?
- (d) What is the resistance of the resistor?



Problem 6 Solve using the following Eqs; $A = A_{max} = \frac{1}{2} L(t)$, $V_{oltage} = IR = \frac{d\phi}{dt}$

$$H = \bar{\alpha} \phi \quad H(\phi) = \frac{\partial \phi}{\partial t} \int 3\pi r^2 dr \text{ for } r > a = \bar{\alpha} \phi \int \frac{3}{2} r dr \text{ for } r < a$$

(17)

$$\oint H \cdot d\ell = I_s = \int 3\pi r^2 dr \text{ for } r < a$$

$$\frac{dI}{dt} = + \frac{5}{4} \pi t \quad (17) = \frac{5}{4} \pi t$$

Given $\phi = 0 \text{ when } x = 0 \text{ since } (x=0)$

$$\frac{d\phi}{dt} = - \oint \bar{J} \cdot d\ell = - \left(\frac{1}{2} \times \frac{1}{2} \right) (5\ell + 0) \text{ J. am at } x = \frac{1}{2} \text{ since } (x=\frac{1}{2})$$

$$\frac{d\phi}{dt} = - \frac{5}{4} \pi t \quad \text{Ans}$$

$$= - \frac{5}{4} \pi t^2 / 2 \quad \text{Ans}$$

$$= - \frac{5}{8} \pi t^3 / 3 \quad \text{Ans}$$

$$= - \frac{5}{24} \pi t^4 / 4 \quad \text{Ans}$$

$$= - \frac{5}{96} \pi t^5 / 5 \quad \text{Ans}$$

$$= - \frac{5}{192} \pi t^6 / 6 \quad \text{Ans}$$

$$= - \frac{5}{384} \pi t^7 / 7 \quad \text{Ans}$$

$$= - \frac{5}{768} \pi t^8 / 8 \quad \text{Ans}$$

$$= - \frac{5}{1536} \pi t^9 / 9 \quad \text{Ans}$$

$$= - \frac{5}{3072} \pi t^{10} / 10 \quad \text{Ans}$$

$$= - \frac{5}{6144} \pi t^{11} / 11 \quad \text{Ans}$$

$$= - \frac{5}{12288} \pi t^{12} / 12 \quad \text{Ans}$$

$$= - \frac{5}{24576} \pi t^{13} / 13 \quad \text{Ans}$$

$$= - \frac{5}{49152} \pi t^{14} / 14 \quad \text{Ans}$$

$$= - \frac{5}{98304} \pi t^{15} / 15 \quad \text{Ans}$$

$$= - \frac{5}{196608} \pi t^{16} / 16 \quad \text{Ans}$$

$$= - \frac{5}{393216} \pi t^{17} / 17 \quad \text{Ans}$$

$$= - \frac{5}{786432} \pi t^{18} / 18 \quad \text{Ans}$$

$$= - \frac{5}{1572864} \pi t^{19} / 19 \quad \text{Ans}$$

$$= - \frac{5}{3145728} \pi t^{20} / 20 \quad \text{Ans}$$

$$= - \frac{5}{6291456} \pi t^{21} / 21 \quad \text{Ans}$$

$$= - \frac{5}{12582912} \pi t^{22} / 22 \quad \text{Ans}$$

$$= - \frac{5}{25165824} \pi t^{23} / 23 \quad \text{Ans}$$

$$= - \frac{5}{50331648} \pi t^{24} / 24 \quad \text{Ans}$$

$$= - \frac{5}{100663296} \pi t^{25} / 25 \quad \text{Ans}$$

$$= - \frac{5}{201326592} \pi t^{26} / 26 \quad \text{Ans}$$

$$= - \frac{5}{402653184} \pi t^{27} / 27 \quad \text{Ans}$$

$$= - \frac{5}{805306368} \pi t^{28} / 28 \quad \text{Ans}$$

$$= - \frac{5}{1610612736} \pi t^{29} / 29 \quad \text{Ans}$$

$$= - \frac{5}{3221225472} \pi t^{30} / 30 \quad \text{Ans}$$

$$= - \frac{5}{6442450944} \pi t^{31} / 31 \quad \text{Ans}$$

$$= - \frac{5}{12884901888} \pi t^{32} / 32 \quad \text{Ans}$$

$$= - \frac{5}{25769803776} \pi t^{33} / 33 \quad \text{Ans}$$

$$= - \frac{5}{51539607552} \pi t^{34} / 34 \quad \text{Ans}$$

$$= - \frac{5}{103079215088} \pi t^{35} / 35 \quad \text{Ans}$$

$$= - \frac{5}{206158430176} \pi t^{36} / 36 \quad \text{Ans}$$

$$= - \frac{5}{412316860352} \pi t^{37} / 37 \quad \text{Ans}$$

$$= - \frac{5}{824633720704} \pi t^{38} / 38 \quad \text{Ans}$$

$$= - \frac{5}{1649267441408} \pi t^{39} / 39 \quad \text{Ans}$$

$$= - \frac{5}{3298534882816} \pi t^{40} / 40 \quad \text{Ans}$$

$$= - \frac{5}{6597069765632} \pi t^{41} / 41 \quad \text{Ans}$$

$$= - \frac{5}{13194139531264} \pi t^{42} / 42 \quad \text{Ans}$$

$$= - \frac{5}{26388279062528} \pi t^{43} / 43 \quad \text{Ans}$$

$$= - \frac{5}{52776558125056} \pi t^{44} / 44 \quad \text{Ans}$$

$$= - \frac{5}{10555311625112} \pi t^{45} / 45 \quad \text{Ans}$$

$$= - \frac{5}{21110623250224} \pi t^{46} / 46 \quad \text{Ans}$$

$$= - \frac{5}{42221246500448} \pi t^{47} / 47 \quad \text{Ans}$$

$$= - \frac{5}{84442493000896} \pi t^{48} / 48 \quad \text{Ans}$$

$$= - \frac{5}{168884986001792} \pi t^{49} / 49 \quad \text{Ans}$$

$$= - \frac{5}{337769972003584} \pi t^{50} / 50 \quad \text{Ans}$$

$$= - \frac{5}{675539944007168} \pi t^{51} / 51 \quad \text{Ans}$$

$$= - \frac{5}{1351079888014336} \pi t^{52} / 52 \quad \text{Ans}$$

$$= - \frac{5}{2702159776028672} \pi t^{53} / 53 \quad \text{Ans}$$

$$= - \frac{5}{5404319552057344} \pi t^{54} / 54 \quad \text{Ans}$$

$$= - \frac{5}{10808639104114688} \pi t^{55} / 55 \quad \text{Ans}$$

$$= - \frac{5}{21617278208229376} \pi t^{56} / 56 \quad \text{Ans}$$

$$= - \frac{5}{43234556416458752} \pi t^{57} / 57 \quad \text{Ans}$$

$$= - \frac{5}{86469112832917504} \pi t^{58} / 58 \quad \text{Ans}$$

$$= - \frac{5}{172938225665835008} \pi t^{59} / 59 \quad \text{Ans}$$

$$= - \frac{5}{345876451331670016} \pi t^{60} / 60 \quad \text{Ans}$$

$$= - \frac{5}{691752902663340032} \pi t^{61} / 61 \quad \text{Ans}$$

$$= - \frac{5}{1383505805326680064} \pi t^{62} / 62 \quad \text{Ans}$$

$$= - \frac{5}{2767011610653360128} \pi t^{63} / 63 \quad \text{Ans}$$

$$= - \frac{5}{5534023221306720256} \pi t^{64} / 64 \quad \text{Ans}$$

$$= - \frac{5}{11068046442613440512} \pi t^{65} / 65 \quad \text{Ans}$$

$$= - \frac{5}{22136092885226881024} \pi t^{66} / 66 \quad \text{Ans}$$

$$= - \frac{5}{44272185770453762048} \pi t^{67} / 67 \quad \text{Ans}$$

$$= - \frac{5}{88544371540907524096} \pi t^{68} / 68 \quad \text{Ans}$$

$$= - \frac{5}{177088743081815048192} \pi t^{69} / 69 \quad \text{Ans}$$

$$= - \frac{5}{354177486163630096384} \pi t^{70} / 70 \quad \text{Ans}$$

$$= - \frac{5}{708354972327260192768} \pi t^{71} / 71 \quad \text{Ans}$$

$$= - \frac{5}{1416709944654520385536} \pi t^{72} / 72 \quad \text{Ans}$$

$$= - \frac{5}{2833419889309040771072} \pi t^{73} / 73 \quad \text{Ans}$$

$$= - \frac{5}{5666839778618081542144} \pi t^{74} / 74 \quad \text{Ans}$$

$$= - \frac{5}{11333679557236163084288} \pi t^{75} / 75 \quad \text{Ans}$$

$$= - \frac{5}{22667359114472326168576} \pi t^{76} / 76 \quad \text{Ans}$$

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$$= - \frac{5}{90669436457889304674304} \pi t^{78} / 78 \quad \text{Ans}$$

$$= - \frac{5}{18133887291577860934864} \pi t^{79} / 79 \quad \text{Ans}$$

$$= - \frac{5}{36267774583155721869728} \pi t^{80} / 80 \quad \text{Ans}$$

$$= - \frac{5}{72535549166311443739456} \pi t^{81} / 81 \quad \text{Ans}$$

$$= - \frac{5}{145071098332622887478912} \pi t^{82} / 82 \quad \text{Ans}$$

$$= - \frac{5}{290142196665245774957824} \pi t^{83} / 83 \quad \text{Ans}$$

$$= - \frac{5}{580284393330491549915648} \pi t^{84} / 84 \quad \text{Ans}$$

$$= - \frac{5}{1160568786660983099831296} \pi t^{85} / 85 \quad \text{Ans}$$

$$= - \frac{5}{2321137573321966199662592} \pi t^{86} / 86 \quad \text{Ans}$$

$$= - \frac{5}{4642275146643932399325184} \pi t^{87} / 87 \quad \text{Ans}$$

$$= - \frac{5}{9284550293287864798650368} \pi t^{88} / 88 \quad \text{Ans}$$

$$= - \frac{5}{18569100586575729597300736} \pi t^{89} / 89 \quad \text{Ans}$$

$$= - \frac{5}{37138201173151459194601472} \pi t^{90} / 90 \quad \text{Ans}$$

$$= - \frac{5}{74276402346302918389202944} \pi t^{91} / 91 \quad \text{Ans}$$

$$= - \frac{5}{148552804692605836778405888} \pi t^{92} / 92 \quad \text{Ans}$$

$$= - \frac{5}{297105609385211673556811776} \pi t^{93} / 93 \quad \text{Ans}$$

$$= - \frac{5}{594211218770423347113623552} \pi t^{94} / 94 \quad \text{Ans}$$

$$= - \frac{5}{1188422437540846694227247104} \pi t^{95} / 95 \quad \text{Ans}$$

$$= - \frac{5}{2376844875081693388454494208} \pi t^{96} / 96 \quad \text{Ans}$$

$$= - \frac{5}{4753689750163386776908988416} \pi t^{97} / 97 \quad \text{Ans}$$

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$$= - \frac{5}{19014759000653547107635953664} \pi t^{99} / 99 \quad \text{Ans}$$

$$= - \frac{5}{38029518001307094215271907328} \pi t^{100} / 100 \quad \text{Ans}$$

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$$= - \frac{5}{152118072005228368861087629312} \pi t^{102} / 102 \quad \text{Ans}$$

$$= - \frac{5}{304236144010456737722175258624} \pi t^{103} / 103 \quad \text{Ans}$$

$$= - \frac{5}{608472288020913475444350517248} \pi t^{104} / 104 \quad \text{Ans}$$

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$$= - \frac{5}{2433889152083653901777402068992} \pi t^{106} / 106 \quad \text{Ans}$$

$$= - \frac{5}{4867778304167307803554804037984} \pi t^{107} / 107 \quad \text{Ans}$$

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$$= - \frac{5}{2492302491733661595419739667456} \pi t^{116} / 116 \quad \text{Ans}$$

$$= - \frac{5}{4984604983467323190839479334912} \pi t^{117} / 117 \quad \text{Ans}$$

$$= - \frac{5}{9969209966934646381678958669824} \pi t^{118} / 118 \quad \text{Ans}$$

$$= - \frac{5}{19938419933869292763357917339648} \pi t^{119} / 119 \quad \text{Ans}$$

$$= - \frac{5}{39876839867738585526715834679296} \pi t^{120} / 120 \quad \text{Ans}$$

$$= - \frac{5}{79753679735477171053431669358592} \pi t^{121} / 121 \quad \text{Ans}$$

$$= - \frac{5}{159507359470954342106863338717184} \pi t^{122} / 122 \quad \text{Ans}$$

$$= - \frac{5}{319014718941908684213726677434368} \pi t^{123} / 123 \quad \text{Ans}$$

$$= - \frac{5}{638029437883817368427453354868736} \pi t^{124} / 124 \quad \text{Ans}$$

$$= - \frac{5}{127605887576763473685490670973752} \pi t^{125} / 125 \quad \text{Ans}$$

$$= - \frac{5}{255211775153526947370981341947504} \pi t^{126} / 126 \quad \text{Ans}$$

$$= - \frac{5}{510423550307053894741962683895008} \pi t^{127} / 127 \quad \text{Ans}$$

$$= - \frac{5}{1020847100614107789483925367790016} \pi t^{128} / 128 \quad \text{Ans}$$

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$$= - \frac{5}{4083388402456431157935701471160064} \pi t^{130} / 130 \quad \text{Ans}$$

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$$= - \frac{5}{65334214439302898526971223536641024} \pi t^{134} / 134 \quad \text{Ans}$$

$$= - \frac{5}{130668428878605797053944447073282048} \pi t^{135$$