Make sure to fill out the grading sheet completely including your name, instructor, exam flavor and UIN. You are allowed to write and work on this exam copy, but your answers must be bubbled in on the grading sheet to receive credit. Your bubbled responses are the only responses that will be considered for the grade.

Physics 207 Comprehensive Exam – Flavor 1

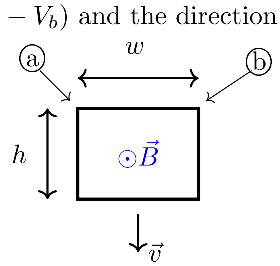
Problem 1 (6 points) In a region of space the electric field is described by $\vec{E} = (8x\hat{\imath} + 10\hat{\jmath})\frac{N}{m}$. Compute the difference on electric potential V(x=0,y=0) - V(x=3m, y=3m). (Hint: you might want to consider a path from (0,0) to (3m,0) to (3m,3m))

A) 6 Volts
B) 28 Volts
C) 30 Volts
D) 36 Volts
E) 66 Volts

Problem 2 (4 points) The following represent several charge distributions all with a radius R and total charge Q. In which case is the electric field for $r > R$ ***NOT*** $\frac{kQ}{r^2}\hat{r}$?

A) A spherical insulator with $\rho(r) = \rho_0$ and total charge Q.
B) A spherical insulator with $\rho(r) = \rho_0 r^2$ and total charge Q.
C) A spherical insulator with $\rho(\theta) = \rho_0 \sin\theta$ and total charge Q.
D) A solid spherical conductor with total charge Q.
E) A thin spherical conducting shell with total charge Q.

Problem 3 (6 points) A rectangular loop of width w and height h is falling with a velocity v while being fully embedded in a constant magnetic field, B, coming out of the page. Find the induced voltage difference between the corners ⓐ and ⓑ ($V_a - V_b$) and the direction of the current induced in the loop.



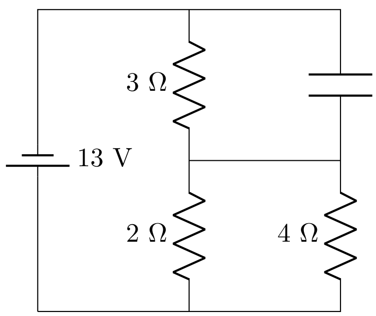
A) Voltage = vBw, Current: No induced current
B) Voltage = vBw, Current: clockwise
C) Voltage = vBw, Current: counterclockwise
D) Voltage = $vB2w$, Current: No induced current
E) Voltage = $vB2w$, Current: clockwise
F) Voltage = $vB2w$, Current: counterclockwise
G) Voltage = $vBwh$, Current: No induced current
H) Voltage = $vBwh$, Current: clockwise

Problem 4 (6 points) Three capacitors ($C_1 = 2\ \mu F, C_2 = 4\mu F, C_3 = 8\mu F$) are connected in series to a 7 V battery. Find the charge Q_2 and the voltage V_2 over C_2.

A) $Q_2 = \frac{8}{7}\ \mu\text{C},\ V_2 = \frac{2}{7}$ V
B) $Q_2 = \frac{8}{7}\ \mu\text{C},\ V_2 = \frac{8}{7}$ V
C) $Q_2 = 8\ \mu\text{C},\ V_2 = 7$ V
D) $Q_2 = 8\ \mu\text{C},\ V_2 = 2$ V
E) $Q_2 = 49\ \mu\text{C},\ V_2 = 2$ V
F) $Q_2 = 49\ \mu\text{C},\ V_2 = \frac{4}{7}$ V

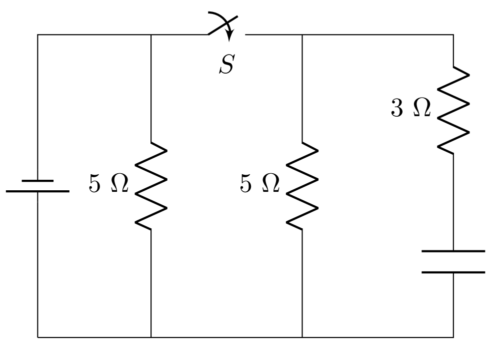
Problem 5 (6 points) For the circuit below, find the current going through the battery, I, and the voltage on the capacitor V_c knowing that the circuit has been connected for a long time.

A) $I = \frac{13}{9}$ A, $V_c = \frac{13}{3}$ V
B) $I = \frac{13}{6}$ A, $V_c = 0$ V
C) $I = \frac{13}{5}$ A, $V_c = \frac{39}{5}$ V
D) $I = 3$ A, $V_c = 9$ V
E) $I = 5$ A, $V_c = 15$ V



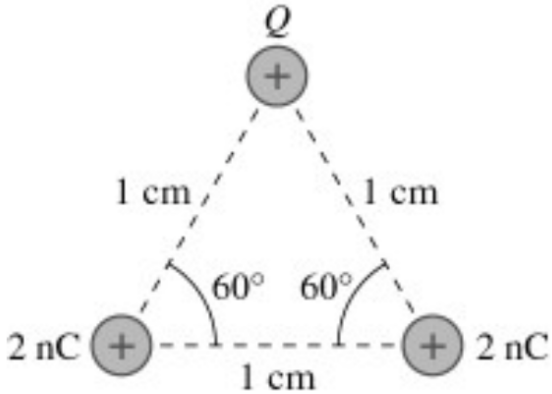
Problem 6 (4 points) In the circuit below when the switch S is closed the capacitor charges over time and when the switch is opened the capacitor discharges over time. Find the ratio of the time constant of charging vs discharging, $\frac{\tau_{charging}}{\tau_{discharging}}$

A) 3/5
B) 3/10
C) 1
D) 5/3
E) 3/8
F) 11/16
G) 8/3



Problem 7 (6 points) In the figure below $Q = 5.8$ nC. What is the magnitude of the force on the charge Q?

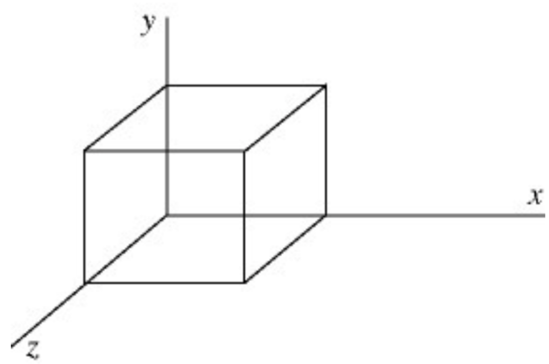
A) 9.0×10^{-4} N
B) 1.8×10^{-3} N
C) 1.2×10^{-3} N
D) 1.0×10^{-3} N



Problem 8 (6 points) In the previous problem, assume that both the 2 nC charges are fixed in place and cannot move. If Q is released from rest, and it has a mass of 1 mg, what is its speed when it is infinitely far away from the other charges?
A) 71 m/s
B) 42 m/s
C) 13 m/s
D) 6.5 m/s
E) 4.6 m/s

Problem 9 (6 points) The cube of insulating material shown in the figure has one corner at the origin. Each side of the cube has length 0.080 m so the top face of the cube is parallel to the xz-plane and is at $y = 0.080$ m. It is observed that there is an electric field $\vec{E} = (3280y)\hat{\jmath}$ (in V/m) that is in the $+y-$direction and whose magnitude depends only on y. Calculate the net charge enclosed by the cube.

A) 1.5×10^{-11} C
B) 2.7×10^{-11} C
C) 3.1×10^{-11} C
D) 6.9×10^{-11} C
E) 8.3×10^{-11} C



Problem 10 (6 points) Consider a surface charge distribution placed in the xy-plane as in the figure below. The distribution infinitely extends along x-direction and has thickness H along y-direction. The uniform surface charge density is σ. Calculate the magnitude of the electric field at a distance D in the xy-plane. (Hint: The electric field of a uniform infinite line charge having charge per unit length λ is given by $E = 2k\lambda/y$, where y is the distance from the line).

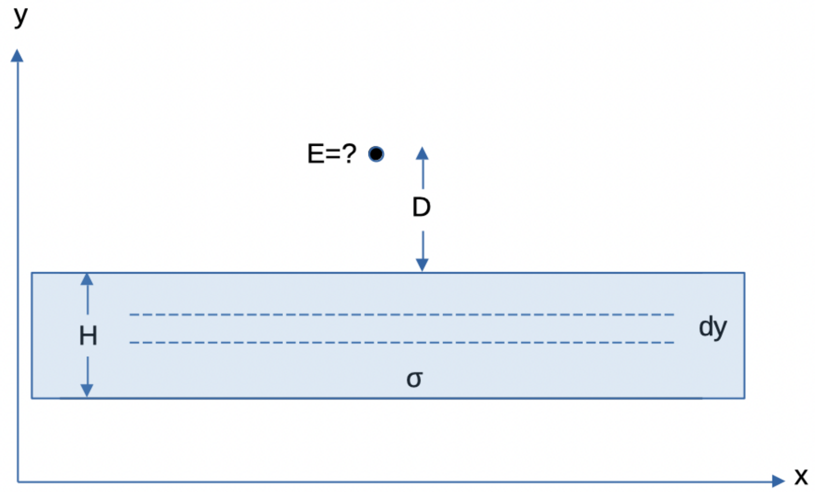
A) $E = 2k\sigma\left(\frac{D+H}{D}\right)^2$

B) $E = 2k\sigma\left(\frac{D+H}{D}\right)$

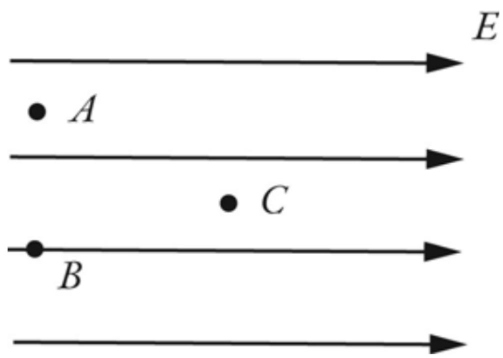
C) $E = 2k\sigma\left(\frac{1}{D}\right)$

D) $E = 2k\sigma\left(\frac{1}{H}\right)$

E) $E = 2k\sigma\ln\left(\frac{D+H}{D}\right)$



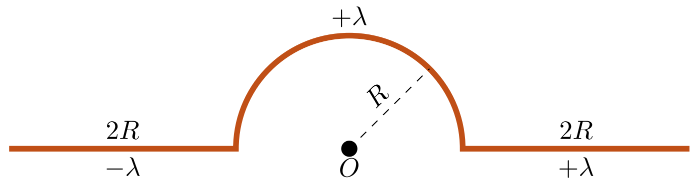
Problem 11 (4 points) Suppose a region of space has a *uniform electric field,* directed towards the right, as shown in the figure. Which statement about the electric potential is true?



A) The potential at all three locations (A, B, C) is the same because the field is uniform.
B) The potential at points A and B are equal, and the potential at point C is higher than the potential at point A.
C) The potential at points A and B are equal, and the potential at point C is lower than the potential at point A.
D) The potential at point A is the highest, the potential at point B is the second highest, and the potential at point C is the lowest.
E) The potential at point A is the highest, the potential at point C is the second highest, and the potential at point B is the lowest.

Problem 12 (6 points) A wire of finite length is bent into the shape shown in the figure below. The left piece which is $2R$ long has a uniform charge density $-\lambda$ while the rest of the object has a uniform charge density $+\lambda$. Find the electric potential at point O.

A) $V = \pi k\lambda$
B) $V = (\pi + 4)k\lambda$
C) $V = \pi k\lambda/R$
D) $V = k\lambda/5R$
E) $V = (\pi + 4)k\lambda R$



Problem 13 (6 points) An electron is traveling with velocity vector $\vec{v} = 350\hat{\imath}$ in SI units. What is the magnitude of the magnetic field at the origin due to the electron when it is at the position $(-0.040, 0.025, 0.000)$ where this position is in m?
A) 7.1×10^{-21} T
B) 1.3×10^{-21} T
C) 2.4×10^{-22} T
D) 6.3×10^{-23} T
E) 4.1×10^{-23} T

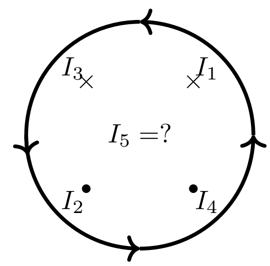
Problem 14 (3 points) In the previous problem, what is the direction of the magnetic field at the origin?
A) $+\hat{\imath}$
B) $+\hat{\jmath}$
C) $+\hat{k}$
D) $-\hat{\imath}$
E) $-\hat{\jmath}$
F) $-\hat{k}$

Problem 15 (5 points) The electric field for a plane-polarized EM wave is given by the equation: $\vec{E}(y,t) = E_0 \sin(ky + \omega t)\hat{k}$. What is the corresponding equation for the magnetic field?
A) $\vec{B}(y,t) = +B_0 \sin(ky - \omega t)\hat{k}$
B) $\vec{B}(y,t) = -B_0 \sin(ky - \omega t)\hat{k}$
C) $\vec{B}(y,t) = +B_0 \sin(ky + \omega t)\hat{k}$
D) $\vec{B}(y,t) = -B_0 \sin(ky + \omega t)\hat{k}$
E) $\vec{B}(y,t) = +B_0 \sin(ky - \omega t)\hat{\imath}$
F) $\vec{B}(y,t) = -B_0 \sin(ky - \omega t)\hat{\imath}$
G) $\vec{B}(y,t) = +B_0 \sin(ky + \omega t)\hat{\imath}$
H) $\vec{B}(y,t) = -B_0 \sin(ky + \omega t)\hat{\imath}$

Problem 16 (5 points) The line integral of the magnetic field around a counterclockwise closed loop is 5.65×10^{-6} Tm. If there are five wires carrying current that pass through this enclosed region, what is the current in I_5 if the other four are known and given below?

$I_1 = 5.6$ A
$I_2 = 3.5$ A
$I_3 = 1.7$ A
$I_4 = 8.1$ A

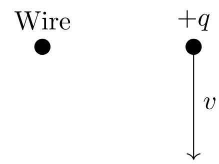
A) 0.2 A out of the page
B) 0.2 A into the page
C) 2.7 A out of the page
D) 2.7 A into the page
E) 4.9 A out of the page
F) 4.9 A into the page
G) 8.8 A out of the page
H) 8.8 A into the page



Problem 17 (6 points) An simple RL series circuit is constructed using a 180 Ω resistor and a 12.0 V battery. When you complete the circuit, it takes 1.50 ms for the current to ramp up to 25.0 mA. What is the inductance of the inductor in the circuit?
A) 0.792 H
B) 0.574 H
C) 0.411 H
D) 0.275 H

Problem 18 (4 points) In the figure below a long wire is carrying a current out of the page. There is a positive charge to the right of the wire, which has a velocity downwards. What is the direction of the magnetic force on the charge, due to the long wire?

A) To the right
B) To the left
C) Upwards
D) Downwards
E) Out of the page
F) Into the page
G) The force is zero



Problem 19 (5 points) Saturn's average distance from the sun is about 9.5 times Earth's. The intensity of light at Earth is about 1390 W/m^2. What is the maximum magnetic field of the light that hits Saturn?

A) 2.42×10^{-6} T
B) 1.11×10^{-6} T
C) 9.64×10^{-7} T
D) 5.03×10^{-7} T
E) 3.59×10^{-7} T