PHYSICS 241/261

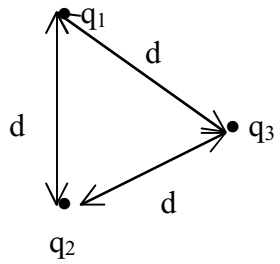
FINAL EXAM **July 26, 2002**

This is a closed book exam. Print and encode your name, student ID number, and recitation number on the answer sheet. Answers to all questions are to be recorded on the answer sheet. There are 24 multiple-choice problems for a total of 200 points. Do not do the problems in the order in which they are given. Do the easy problems first. There is only one correct answer to each question. No penalty for a wrong answer. However, all credit for a question will be lost if more than one choice is marked for that question. You may use your crib sheet and your calculator. Fill out the op-scan card gradually, as soon as you finish the problem. Do not wait filling out the op-scan card during the last hectic five minutes!

USEFUL CONSTANTS:

$k=8.99\times10^{9}$ (Nm^2/C^2)
$\varepsilon_0=8.85\times10^{-12}$ (C^2/Nm^2)
$e=1.609\times10^{-19}$ C
$m_e=9.11\times10^{-31}$ Kg
$g=9.81$ m/s^2
$m_p=1.67\times10^{-27}$ Kg
$\mu_0/4\pi=10^{-7}$ Tm/A
$c=3.00\times10^{8}$ m/s

1) Given the system of charges in the figure find what s the magnitude of the force acting on the charge q_3 with q_1=1μC, q_2=2μC, q_3=3μC and d=20 cm. (5 pts)



a) 3.12 N
b) 1.75N
c) 4.23 N
d) 3.00 N
e) 2.03 N

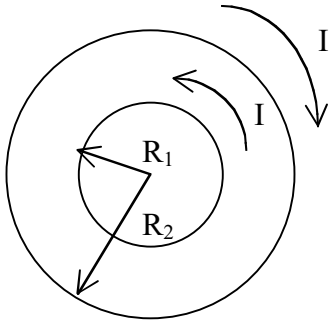
2) A charged ring has radius R=20cm and a charge Q=3C uniformly distributed all over its length. Find the value of the electric field at a point P distant 10 cm from the center of the ring along its central axis? (5 pts)

a) 1.02×10^{11} N/C
b) 2.04×10^{11} N/C
c) 2.41×10^{11} N/C
d) 1.52×10^{11} N/C
e) 1.02×10^{11} N/C

3) A charge q=3C moves with speed v=3.0i+2.0j+5.0k m/s inside a magnetic field B=1.0i-3.0j+4.0k T. Calculate the force acting on it. (5 pts)

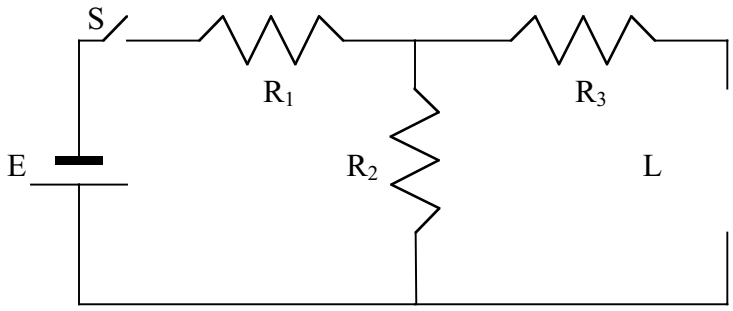
a) -69i + 21j + 33k N
b) 10i + 14j + 12k N
c) -12i + 24j - 12k N
d) 69i - 21j - 33k N
e) -11i - 12j - 13k N

4) Two concentric circular loops of radii R_1=5cm and R_2=10cm carry equal antiparallel currents I=5A as in the figure below. Calculate the magnitude of the total magnetic field in the center C (See fig.). (5 pts)



a) $3.14\ 10^{-5}$ T
b) $1.17\ 10^{-5}$ T
c) $8.33\ 10^{-4}$ T
d) $7.42\ 10^{-6}$ T
e) $6.42\ 10^{-6}$ T

5) Calculate the power supplied by the battery when the switch is just closed. Assume E=4V, R_1=10Ω, R_2=20Ω, R_3=15Ω and L=15H. (5 pts)



a) 0.10 W
b) 0.86W
c) 0.21 W
d) 0.13 W
e) 0.53 W

6) A RLC series circuit consists of a R=1kΩ resistor, a C=1μF capacitor and a L=0.2H inductor connected to a V=150sinωt source. What is the current delivered by the source at resonance? (5 pts)

a) 20.3 mA
b) 54.3 mA
c) 15.0 mA
d) 10.3 mA
e) 150 mA

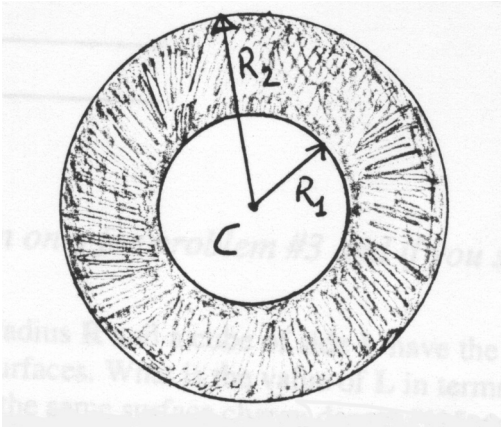
7) A solar sail of area $A=200m^2$ is at a distance $d=1.46\times10^8$ km from the sun. Suppose the power of the sun is 10^{20} kW and the sail is perfectly reflecting and has a mass m=10 Kg. Calculate the acceleration of the sail at that point in space. (5 pts)

a) 3.45×10^{-8} m/s^2
b) 4.45×10^{-8} m/s^2
c) 4.98×10^{-8} m/s^2
d) 3.75×10^{-8} m/s^2
e) 2.49×10^{-8} m/s^2

8) What s the speed of an electromagnetic wave in the vacuum? (5 pts)

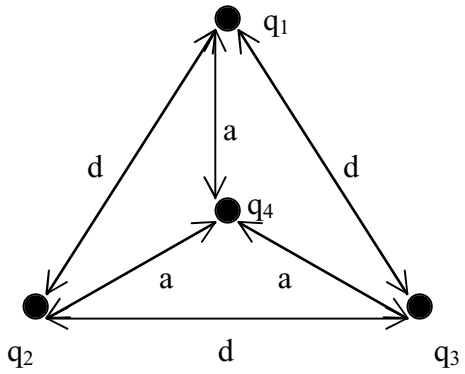
a) 0 m/s
b) 3×10^{8} m/s
c) 2×10^{5} m/s
d) 3×10^{5} m/s
e) 1×10^{8} m/s

9) A thick spherical shell of radii R_1=5 cm and R_2=10 cm has a charge Q=2C uniformly distributed through the volume. Find the electric field produced by the charge distribution at a point P distant r=7.5cm from the center of the shell.(7.5 pts)



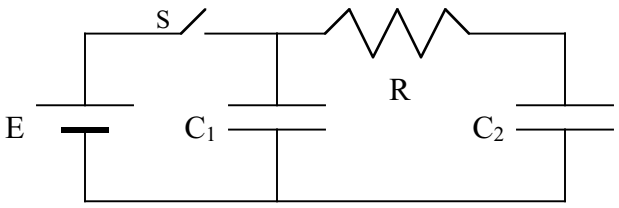
a) 4.08×10^{12} N/C
b) 2.04×10^{12} N/C
c) 3.03×10^{12} N/C
d) 1.08×10^{12} N/C
e) 5.05×10^{12} N/C

10) Calculate the electric potential energy of the system of charges shown in the picture below where $q_1=2\mu C$, $q_2=3\mu C$, $q_3=4\mu C$, $q_4=5\mu C$, d=15cm and a=8.66cm. (7.5 pts)



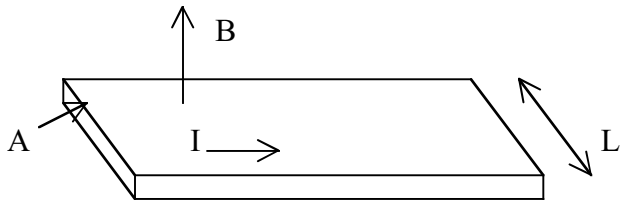
a) 6.23 J
b) 3.18 J
c) 10.4 J
d) 2.45 J
e) 45.6 J

11) What s the total energy stored in the circuit when the switch has been closed for t=0.2s? E=10V, R=10kΩ, C_1=2μF and C_2=4μF. (7.5 pts)



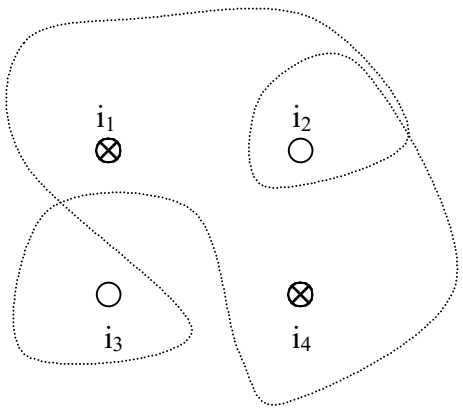
a) 1.00×10^{-4} J
b) 1.97×10^{-4} J
c) 2.97×10^{-4} J
d) zero J
e) 1.5×10^{-4} J

12) A metal slab of length L=50cm and cross section A=10cm^2 carries a current I=5mA. A magnetic field B=0.5T is applied perpendicularly to the direction of the current. A Hall potential difference V=0.2V is measured in the transverse direction. Find the density of electrons n for the slab. (7.5 pts)



a) 3.03×10^{12} C/m^3
b) 4.02×10^{22} C/m^3
c) 3.55×10^{19} C/m^3
d) 2.88×10^{23} C/m^3
e) 3.88×10^{19} C/m^3

13) Calculate the value of the line integral $\int B\, dl$ along the path indicated in the figure when $i_1=2A$, $i_2=1A$, $i_3=4A$, $i_4=3A$. (7.5 pts)



a) 1.56×10^{-5} Tm
b) 8.80×10^{-6} Tm
c) 1.38×10^{-5} Tm
d) 2.56×10^{-5} Tm
e) 1.56×10^{-4} Tm

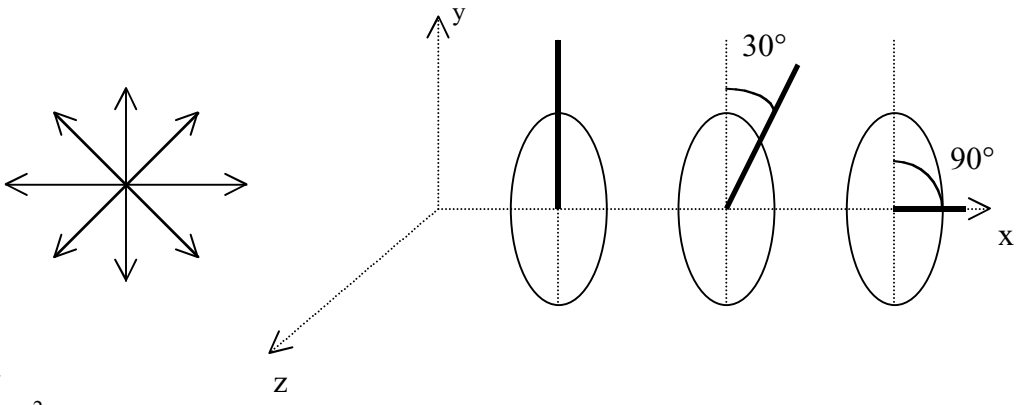
14) A very long solenoid of number of turns per unit length $n=1000m^{-1}$ carries a current i=2A. What s the magnetic energy density stored in the magnetic field? (7.5 pts)

a) 4.22 J/m^3
b) 3.16 J/m^3
c) 2.22 J/m^3
d) 2.51 J/m^3
e) 5.12 J/m^3

15) Given the LC circuit with L=3mH and C=4pF and total potential energy stored U=20mJ, (all the energy is initially stored in the inductor) calculate the charge stored in the capacitor at t=3ms. (7.5 pts)

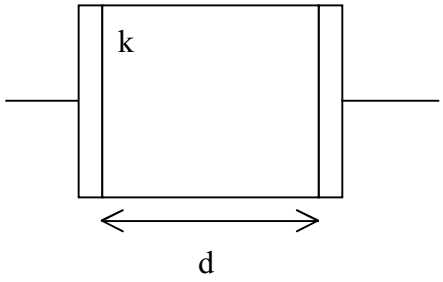
a) 2.50×10^{-7} C
b) 2.70×10^{-7} C
c) -1.76×10^{-8} C
d) 3.43×10^{-7} C
e) -2.76×10^{-7} C

16) A completely unpolarized beam of light passes through three polarizing sheets (See picture). If the intensity of the initial beam is 10 W/m^2, what is the intensity of the final beam? (7.5 pts)



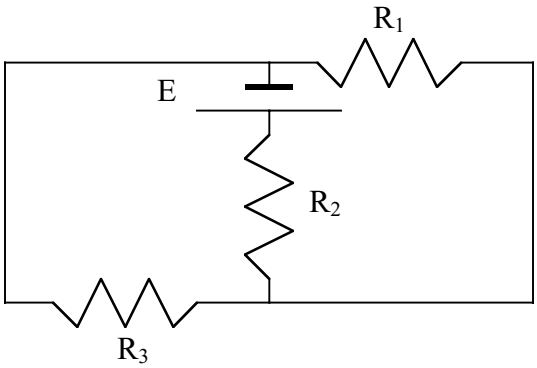
a) 0 W/m^2
b) 2.50 W/m^2
c) 5.05 W/m^2
d) 4.02 W/m^2
e) 0.94 W/m^2

17) The following picture shows a parallel plate capacitor of plate area $A=0.1m^2$ and plate separation d=1cm. The space between the plates is filled with a dielectric slab of dielectric constant k=4. If the voltage across the capacitor is V=2V, what s the magnitude of the electric field due to the induced charge on the top face of the dielectric? (12.5 pts)



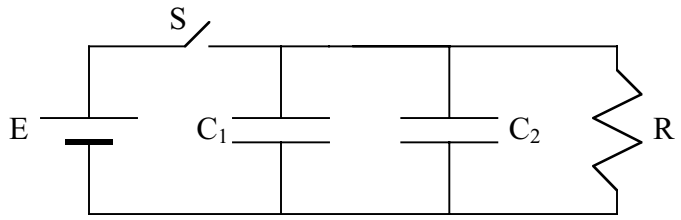
a) 133 N/C
b) 600 N/C
c) 531 N/C
d) 244 N/C
e) 112 N/C

18) What is the total power dissipated in the circuit below? E=5V, R_1=20Ω, R_2=40Ω, R_3=60Ω. (12.5 pts)



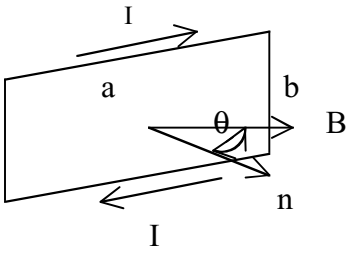
a) 5.29 W
b) 3.33 W
c) 2.44 W
d) 0.31 W
e) 1.23 W

19) In the circuit below the switch is opened after that the capacitors have been totally charged. Calculate the voltage across the resistor at a time t=3ms after that the switch has been opened. E=5V, R=5kΩ, C_1=3μC and C_2=6μC. (12.5 pts)



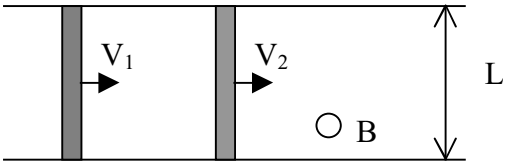
a) 4.33 V
b) 5.33 V
c) 4.68 V
d) 3.00 V
e) 2.33 V

20) The figure shows a current loop carrying a current I=2A. The sides of the loop are respectively equal to a=5cm and b=3cm. A uniform magnetic field B=2T is present and makes an angle θ=20° with the normal. Calculate the magnitude of the torque acting on this loop. (12.5 pts)



a) 2.05×10^{-3} Nm
b) 1.82×10^{-3} Nm
c) 5.01×10^{-3} Nm
d) 3.41×10^{-3} Nm
e) 4.20×10^{-3} Nm

21) Two metal rods of resistance R=3kΩ each move along two conductive rails with constant velocities v_1=2m/s and v_2=5m/s respectively. The distance between the rails is L=50cm and the magnetic field B=2300 gauss points everywhere out of the page. Calculate the current and the direction of the current. (12.5 pts)



a) 5.75×10^{-5} A; CCW
b) 1.05×10^{-4} A; CCW
c) 4.03×10^{-5} A; CCW
d) 5.75×10^{-5} A; CW
e) 5.01×10^{-5} A; CW

22) As a parallel-plate capacitor with circular plates 10 cm in diameter is being charged. The induced magnetic field at a distance r=30 mm from the axis of the symmetry is B=30Gauss. Calculate the current density of the displacement current in the region between the plates. (12.5pts)

a) $1.70\times10\text{^}6$ A/m^2
b) $1.59\times10\text{^}5$ A/m^2
c) $2.63\times10\text{^}6$ A/m^2
d) $4.64\times10\text{^}6$ A/m^2
e) $1.65\times10\text{^}5$ A/m^2

23) A catfish is in a river 2 m under the water level. The index of refraction of water is 1.33. What is the maximum area (at the water s surface) above the fish that he can see through? (12.5pts)

a) 45.2 m^2
b) 35.5 m^2
c) 15.1 m^2
d) 25.4 m^2
e) 16.3 m^2

24) A concave mirror has a radius of curvature of 35.0 cm. It is positioned so that the (upright) image of a man s face is 2.50 times the size of the face. How far is the mirror from the face? (12.5 pts)

a) 13.3 cm
b) 15.0 cm
c) 10.5 cm
d) 25.0 cm
e) 33.0 cm

Final Exam Answers

Question #	Answer
1	b
2	c
3	d
4	a
5	e
6	e
7	c
8	b
9	d
10	a
11	c
12	e
13	b
14	d
15	a
16	e
17	b
18	d
19	c
20	a
21	d
22	b
23	e
24	c