

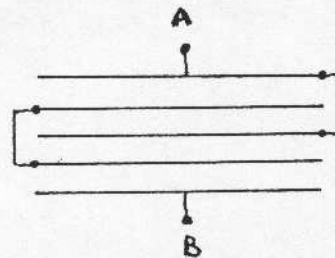
UNIVERSITY OF REGINA
DEPARTMENT OF PHYSICS
PHYSICS 201-001
Final Examination
943



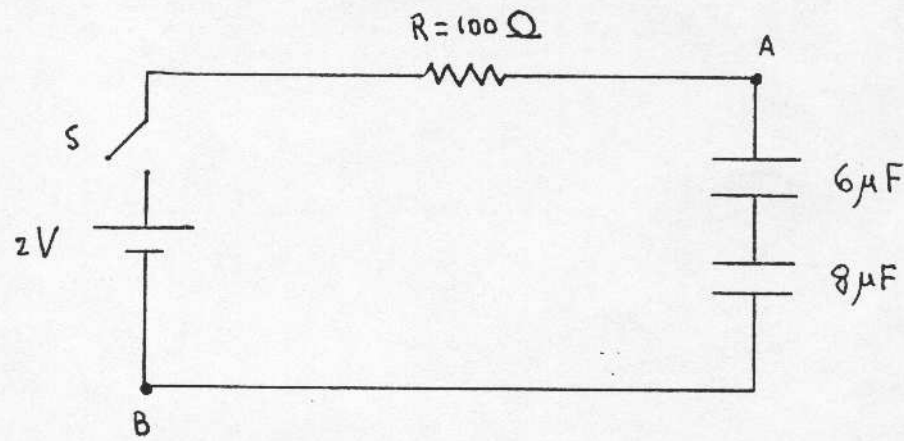
Instructor: Dr. G. Papini
Time: 3 HOURS

Ten questions constitute a complete paper. All questions are of equal value.

- 1. Five parallel circular plates shown below all have the same diameter of 10 cm. The separation between adjacent plates is 1.0 mm and they are connected as indicated in the figure. Calculate the capacitance between points A and B.



- 2. ✓ For the circuit shown below, the battery and the capacitors can be considered to be ideal. If the capacitors are initially discharged and the switch S is closed at t=0, determine the charge on each capacitor and the potential difference $V_A - V_B$ a very long time later.



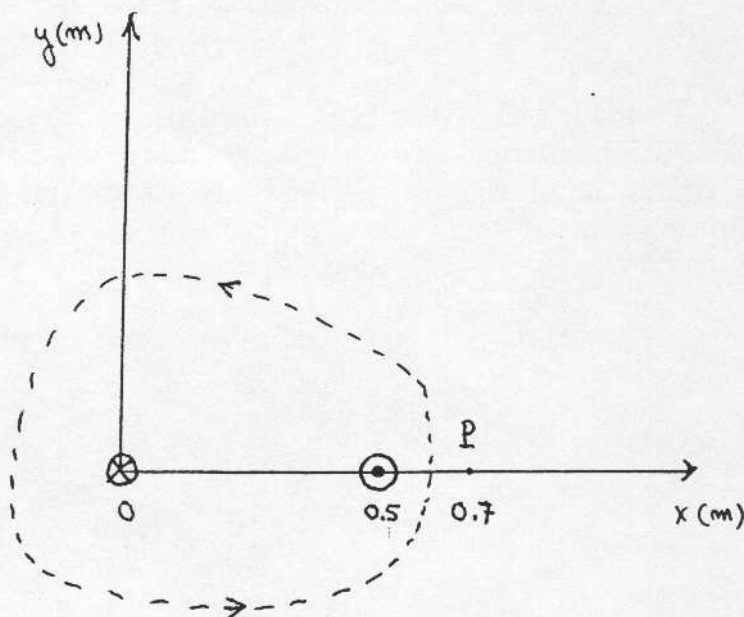
- 3. A parallel-plate air capacitor with plate area A and separation d is connected to a battery of EMF ϵ and negligible internal resistance. Determine the intensity and direction of the force between the plates when the capacitor is fully charged and the battery has been removed.

4. ✓ The charge distribution ρ of a sphere of radius R is represented by the function

$$\rho = \rho_0 \left(1 - \frac{r^2}{R^2} \right) \quad \text{for } r \leq R, \quad \rho = 0 \quad \text{for } r \geq R$$

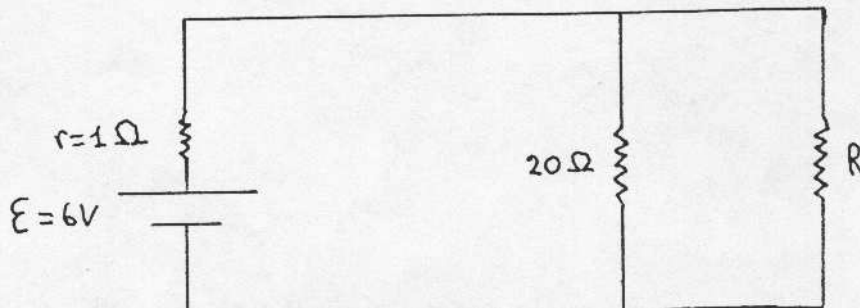
where $\rho_0 = \frac{3Q}{\pi R^3}$ is a positive constant. Find the electric field at all points inside and outside the sphere.

5. ✓ The figure below is a cross-sectional view of two infinitely-long, parallel, solid conductors situated in vacuo. The one at the origin carries a uniformly distributed current $I_1 = 400\text{A}$ directed into the page. The other one at $x = 0.5\text{m}$ carries a current $I_2 = 300\text{A}$ in the opposite sense. Find the magnetic field at the point P ($x = 0.7\text{m}$) and the force per unit length on the conductor at the origin. Find the value of $\oint \vec{B} \cdot d\vec{\ell}$ around the closed path shown (in the counter-clockwise direction).



6. The inner conductor of a coaxial transmission line of length ℓ consists of a metal rod of radius a carrying a uniform current I . The outer conductor is a thin metal tube of radius b in which the same current I flows in the opposite direction. Find the energy stored in the line and the corresponding inductance.

7. ✓ Determine the value of R in the circuit shown such that maximum power is delivered to R .



8. ✓ A thin, non-conducting rod of length $\overline{AB} = L$, with end-point A at the origin and B on the x-axis, carries a charge per unit length $\lambda = ax$, where a is a positive constant. Find the potential at point $P(L+b, 0, 0)$.
 $(L+b, 0, 0)$
9. ✓ A circular loop of wire of radius R carries a steady current I . A uniform magnetic field \vec{B} is perpendicular to the plane of the loop in the direction of the plane normal \hat{n} . Find the tension in the wire.
10. ✓ A car travels due north (magnetic north) at a speed of 100 km/h in a locality where the vertical component of the Earth's magnetic field has a magnitude of $60\mu T$. Calculate the EMF induced between the ends of a 1.2m axle.
11. ✓ An iron ring of radius $a = 10\text{cm}$ and cross-section $A = 16\text{mm}^2$ is placed in a uniform magnetic field of intensity $B = 0.5\text{T}$ generated by an electromagnet. The lines of force of \vec{B} are normal to the plane of the ring. Calculate the amount of charge Q which is set in motion in the ring when the electromagnet is switched off. The resistivity of iron at room temperature is $\rho = 9.68 \times 10^{-8}\Omega\cdot\text{m}$.
12. ✓ A metal bar of mass m slides without friction on two long, parallel conducting rails a distance b apart. A resistor R is connected across the rails at one end and a uniform magnetic field \vec{B} is perpendicular to bar and rails. At time $t = 0$ the bar is at $x = 0$ and is given speed v_0 towards $x > 0$. Find the velocity of the bar for $t > 0$.