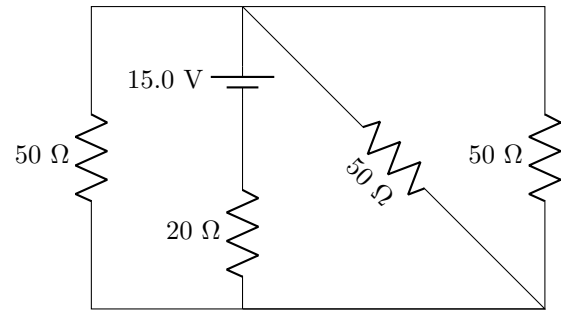


Make sure to fill out the grading sheet completely including your name, instructor, exam flavor and UIN. You are allowed to write and work on this exam copy, but your answers must be bubbled in on the grading sheet to receive credit. Your bubbled responses are the only responses that will be considered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

Physics 207 Exam 2 – Flavor 1

Problem 1 (6 points) What is the current through the $20\ \Omega$ resistor?

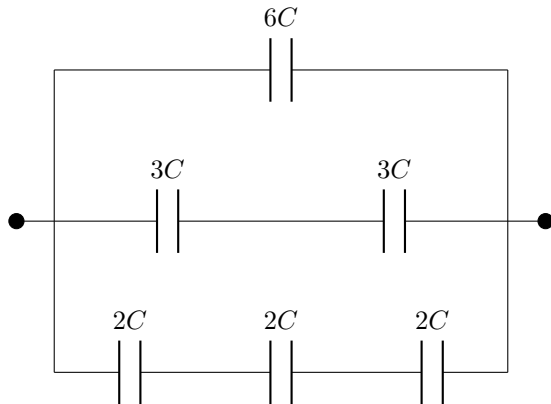
- (A) 0.0585 A
- (B) 0.136 A
- (C) 0.214 A
- (D) 0.409 A
- (E) 0.830 A
- (F) 1.483 A



Problem 2 (6 points) What is the current through the left-most $50\ \Omega$ resistor?

- (A) 0.0585 A
- (B) 0.136 A
- (C) 0.214 A
- (D) 0.409 A
- (E) 0.830 A
- (F) 1.483 A

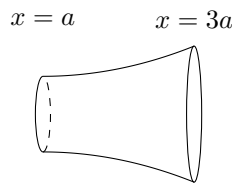
Problem 3 (6 points) What is the effective capacitance of this network?



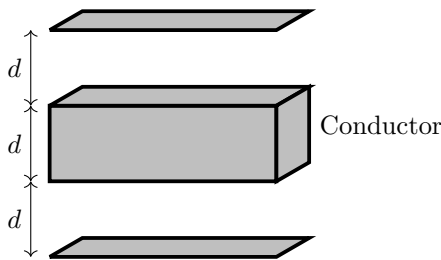
- (A) $0.251C$
- (B) $0.428C$
- (C) $0.860C$
- (D) $2.00C$
- (E) $6.29C$
- (F) $8.17C$
- (G) $10.3C$
- (H) $18.0C$

Problem 4 (8 points) A strange resistor has a parabolic shape where $r(x) = x^2$ where $x = a$ is the left edge of the resistor and it is $2a$ long. If the resistivity of the material is a uniform value ρ_0 , then what is the resistance of this device?

- (A) $\frac{1\rho_0}{3\pi a}$
- (B) $\frac{2\rho_0}{3\pi a}$
- (C) $\frac{2\rho_0}{\pi a}$
- (D) $\frac{1\rho_0}{81\pi a^3}$
- (E) $\frac{2\rho_0}{81\pi a^3}$
- (F) $\frac{2\rho_0}{9\pi a^3}$
- (G) $\frac{26\rho_0}{81\pi a^3}$
- (H) $\frac{2\rho_0}{\pi a^3}$

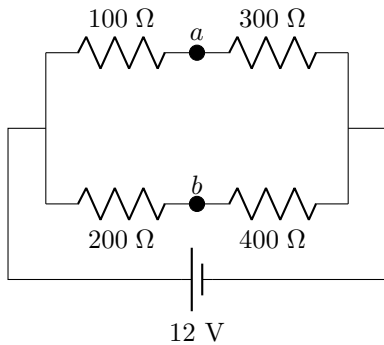


Problem 5 (6 points) A parallel plate capacitor has an area A , a plate separation $3d$ and, when filled with air, has a capacitance C_0 . If we insert a conductor with the same area and a thickness d into the middle, what is the new capacitance?



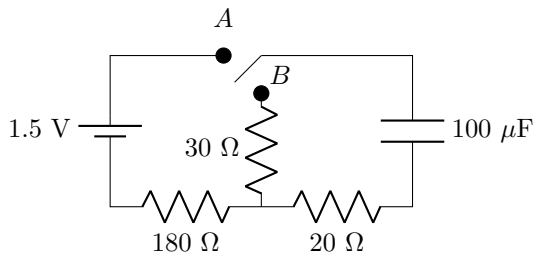
- (A) $C = \frac{1}{3}C_0$
- (B) $C = \frac{1}{2}C_0$
- (C) $C = \frac{2}{3}C_0$
- (D) $C = \frac{3}{2}C_0$
- (E) $C = 2C_0$
- (F) $C = 3C_0$
- (G) This would cause the electric field in this whole region to go to zero resulting in an effective infinite capacitance
- (H) This would cause the capacitor to act like a wire allowing current to flow through resulting in zero capacitance

Problem 6 (6 points) If the potential at point a is defined to be zero, what is the potential at point b in the circuit below?



- (A) +12 V
- (B) +7 V
- (C) +1 V
- (D) 0 V
- (E) -1 V
- (F) -7 V
- (G) -12 V

Problem 7 (8 points) In the following circuit, assume that the switch has been at position A for a long time. It is then moved to position B . How much time will it take for the current in the circuit to reach 11.5 mA?



- (A) 0.116 ms
- (B) 1.53 ms
- (C) 2.42 ms
- (D) 2.86 ms
- (E) 3.33 ms
- (F) 3.75 ms
- (G) 4.08 ms
- (H) 4.79 ms

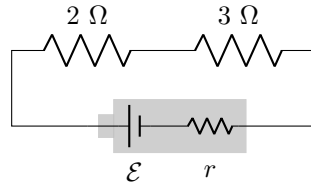
Problem 8 (4 points) In a simple RC -circuit containing only an ideal battery, resistor and capacitor all in series, the capacitor contains a dielectric with constant κ . If the capacitor is fully discharged it will take a time t_κ to charge up to 20% of its maximum charge. If the dielectric is removed leaving air in the capacitor instead, how would the time to reach the same percentage of maximum charge change?

- (A) The time would increase by a factor of κ^2
- (B) The time would increase by a factor of κ
- (C) The time would be the same
- (D) The time would decrease by a factor of κ
- (E) The time would decrease by a factor of κ^2

The following description will be used for Problems 9 and 10. A 12 V battery with an internal resistance of 0.5Ω is connected to two resistors which are in series with each other. The series resistors are 2Ω and 3Ω respectively.

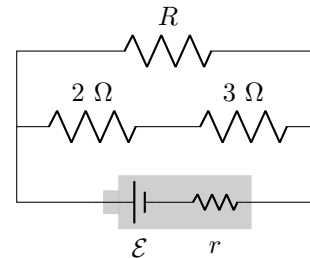
Problem 9 (6 points) What is the terminal voltage that the battery supplies to the circuit?

- (A) $V = 3.45 \text{ V}$
- (B) $V = 5.35 \text{ V}$
- (C) $V = 7.93 \text{ V}$
- (D) $V = 8.47 \text{ V}$
- (E) $V = 9.88 \text{ V}$
- (F) $V = 10.9 \text{ V}$
- (G) $V = 12.0 \text{ V}$
- (H) $V = 15.5 \text{ V}$

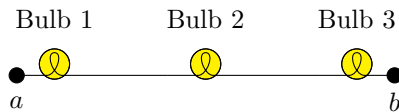


Problem 10 (4 points) If a third resistor, R , is added in parallel to the resistors already in the circuit, what happens to the terminal voltage and the power dissipated in the 2Ω resistor?

- (A) Both stay the same
- (B) Both decrease
- (C) Both increase
- (D) Terminal voltage increases but the power decreases
- (E) Terminal voltage increases but the power stays the same
- (F) Terminal voltage decreases but the power increases
- (G) Terminal voltage decreases but the power stays the same



Problem 11 (6 points) Three light bulbs are connected in series as shown below. When 120 V are applied individually across bulbs 1, 2, and 3 they dissipate 40, 60 and 30 W respectively. When 120 V is applied from a to b , what is the total power dissipated by all three bulbs?

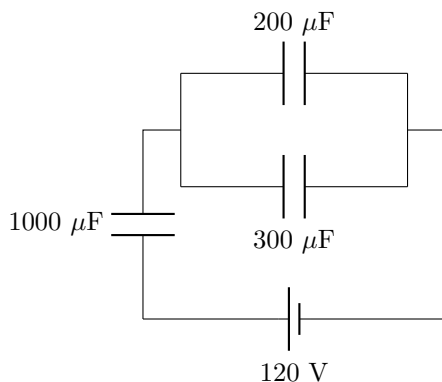


- (A) 1080 W
- (B) 332 W
- (C) 130 W
- (D) 120 W
- (E) 111 W
- (F) 43.3 W
- (G) 13.3 W
- (H) 9.00 W

Problem 12 (4 points) Which of the bulbs burns the brightest when all three are connected in series as pictured in the previous problem?

- (A) Bulb 1
- (B) Bulb 2
- (C) Bulb 3
- (D) They are all the same brightness

Problem 13 (8 points) In the circuit below, what is the charge on the $300 \mu\text{F}$ capacitor?



- (A) 135 mC
- (B) 95.0 mC
- (C) 81.0 mC
- (D) 40.0 mC
- (E) 24.0 mC
- (F) 20.0 mC
- (G) 16.0 mC
- (H) 8.00 mC

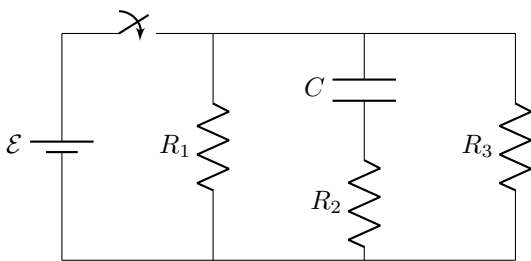
Problem 14 (6 points) A spool of wire holds a 100 m long segment that has a diameter of 0.511 mm. When a 5.00 V difference is applied to the two ends of wire, there is 0.600 A of current passing through the wire. What is the resistivity of this material?

- (A) $1.71 \times 10^{-8} \Omega\text{m}$
- (B) $2.44 \times 10^{-8} \Omega\text{m}$
- (C) $4.10 \times 10^{-8} \Omega\text{m}$
- (D) $6.84 \times 10^{-8} \Omega\text{m}$
- (E) $9.70 \times 10^{-8} \Omega\text{m}$
- (F) $22.0 \times 10^{-8} \Omega\text{m}$
- (G) $40.6 \times 10^{-8} \Omega\text{m}$
- (H) $42.4 \times 10^{-8} \Omega\text{m}$

Problem 15 (6 points) In a parallel plate capacitor, there is a dielectric with constant $\kappa = 6$, a plate area A and separation d . This results in a capacitance C_1 . If the dielectric is removed leaving only air and the distance is decreased by a factor of 4, what is the new capacitance C_2 ?

- (A) $C_2 = \frac{1}{24}C_1$
- (B) $C_2 = \frac{3}{8}C_1$
- (C) $C_2 = \frac{2}{3}C_1$
- (D) $C_2 = C_1$
- (E) $C_2 = \frac{3}{2}C_1$
- (F) $C_2 = \frac{8}{3}C_1$
- (G) $C_2 = 24C_1$

Problem 16 (6 points) What will the current through the battery be a long time after the switch is closed in the circuit below?



- (A) $\frac{\mathcal{E}}{R_1} + \frac{\mathcal{E}}{R_2} + \frac{\mathcal{E}}{R_3}$
- (B) $\frac{\mathcal{E}}{R_1} + \frac{\mathcal{E}}{R_2}$
- (C) $\frac{\mathcal{E}}{R_1} + \frac{\mathcal{E}}{R_3}$
- (D) $\frac{\mathcal{E}}{R_2} + \frac{\mathcal{E}}{R_3}$
- (E) $\frac{\mathcal{E}}{R_1}$
- (F) $\frac{\mathcal{E}}{R_2}$
- (G) $\frac{\mathcal{E}}{R_3}$
- (H) 0

Problem 17 (4 points) A capacitor is connected to a battery and allowed to reach full charge. It is then disconnected from the battery. The plate separation is increased by a constant external force. What is the sign of the work done by this external force?

- (A) Positive
- (B) Zero
- (C) Negative
- (D) There is not enough information

Useful Constants:Acceleration due to gravity: $g = 9.80 \text{ m/s}^2$ Basic unit of charge: $e = 1.6 \times 10^{-19} \text{ C}$ Mass of electron: $m_e = 9.11 \times 10^{-31} \text{ kg}$ Mass of proton/neutron: $m_p = 1.67 \times 10^{-27} \text{ kg}$ Coulomb constant: $k = 8.99 \times 10^9 \text{ Nm}^2/\text{C}^2$ Permittivity of free space: $\epsilon_0 = 1/(4\pi k) = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$ Permeability of free space: $\mu_0 = 4\pi \times 10^{-7} \text{ Tm/A}$ Speed of light in a vacuum: $c = 3 \times 10^8 \text{ m/s}$ Planck's Constant: $h = 6.626 \times 10^{-34} \text{ Js}$ eV to joule conversion: $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$ kilowatt-hour to joule conversion: $1 \text{ kW}\cdot\text{hr} = 3.6 \times 10^6 \text{ J}$ Atomic Mass Unit: $1 \text{ u} = 1.66054 \times 10^{-27} \text{ kg} = 931.5 \text{ MeV}/c^2$

Vector Concepts:Unit Vector: $\hat{r} = \frac{\vec{r}}{r}$ Gradient: $\vec{\nabla} = \frac{\partial}{\partial x}\hat{x} + \frac{\partial}{\partial y}\hat{y} + \frac{\partial}{\partial z}\hat{z}$ Dot Product: $\vec{A} \cdot \vec{B} = |\vec{A}||\vec{B}| \cos \theta$ Dot Product: $\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z$

Cross Product:

$$|\vec{A} \times \vec{B}| = |\vec{A}||\vec{B}| \sin \theta$$

$$\vec{A} \times \vec{B} = (A_y B_z - A_z B_y)\hat{x} - (A_x B_z - A_z B_x)\hat{y} + (A_x B_y - A_y B_x)\hat{z}$$

Sample Indefinite Integrals:

$$\int \frac{dx}{\sqrt{x^2 \pm a^2}} = \ln(x + \sqrt{x^2 \pm a^2}) + c$$

$$\int \frac{xdx}{(x^2 + a^2)^{3/2}} = -\frac{1}{\sqrt{x^2 + a^2}} + c$$

$$\int \frac{dx}{(x^2 + a^2)^{3/2}} = \frac{x}{a^2 \sqrt{x^2 + a^2}} + c$$

$$\int x^n dx = \frac{x^{n+1}}{n+1} + c (n \neq -1)$$

$$\int \frac{dx}{x} = \ln(x) + c$$

$$\int \frac{dx}{x^2 + a^2} = \frac{1}{a} \arctan \frac{x}{a} + c$$

$$\int \frac{dx}{\sqrt{a^2 - x^2}} = \arcsin \frac{x}{a} + c$$

SI Prefixes:T= $\times 10^{12}$, G= $\times 10^9$, M= $\times 10^6$, k= $\times 10^3$ c= $\times 10^{-2}$, m= $\times 10^{-3}$ μ = $\times 10^{-6}$, n= $\times 10^{-9}$, p= $\times 10^{-12}$, f= $\times 10^{-15}$

Useful integral relationships:Spherical: $dV = 4\pi r^2 dr$ Cylindrical (with constant r): $dV = \pi r^2 dz$ Cylindrical (with constant z): $dV = z 2\pi r dr$ Cylindrical (with constant r): $dA = 2\pi r dz$ Cylindrical (with constant z): $dA = 2\pi r dr$

Geometry:Surface Area of a Sphere: $A = 4\pi r^2$ Volume of a Sphere: $V = \frac{4}{3}\pi r^3$ Area of curved region of a cylinder: $A = 2\pi r h$ Volume of a cylinder: $V = \pi r^2 h$

Physics 1 Concepts:Work: $W = \int \vec{F} \cdot d\vec{\ell}$

Potential Energy of conservative force:

 $W_{cons} = -\Delta U$ Kinetic Energy: $K = \frac{1}{2}mv^2$ Momentum: $\vec{p} = m\vec{v}$

Chapter 21:

Coulomb's Law [N]: $\vec{F} = \frac{kq_1q_2}{r^2}\hat{r}$

Force due to an electric field [N]: $\vec{F} = q\vec{E}$

E Field due to a pt. charge [N/C]: $\vec{E} = \frac{kq}{r^2}\hat{r}$

E Field due to a continuous charge dist. [N/C]:

$$\vec{E} = \int \frac{k dq}{r^2} \hat{r}$$

Electric dipole moment [Cm]: $\vec{p} = q\vec{d}$

Torque on an electric dipole [Nm]: $\vec{\tau} = \vec{p} \times \vec{E}$

Electric pot. energy stored in electric dipole [J]:

$$U = -\vec{p} \cdot \vec{E}$$

Chapter 22:

Electric Flux [Vm or Nm²/C]: $\Phi_E = \int \vec{E} \cdot d\vec{A}$

Electric Flux when E and θ are const.

on the surface: $\Phi_E = EA \cos \theta$

Gauss's Law (vacuum): $\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{encl}}}{\epsilon_0}$

Chapter 23: The below equations generally but not always assume that $V(\infty) = 0$ and/or $U(\infty) = 0$.

Elec. pot. energy between 2 pt charges [J]:

$$U = \frac{kq_1q_2}{r}$$

Elec. pot. difference btw. two locations [V or J/C]:

$$\Delta V = \frac{\Delta U}{q} \text{ (or often) } V = \frac{U}{q}$$

Electric potential due to a point charge [V]:

$$V = \frac{kq}{r}$$

Electric potential due to a charge dist. [V]:

$$V = \int \frac{k dq}{r}$$

Relating \vec{E} and V : $\vec{E} = -\vec{\nabla}V$

$$\Delta V = V_b - V_a = - \int_a^b \vec{E} \cdot d\vec{\ell}$$

Chapter 24:

Capacitance [F]: $Q = CV$

Capacitance for Parallel Plates [F]: $C = \frac{\kappa\epsilon_0 A}{d}$

Energy stored in a capacitor [J]: $U = \frac{1}{2}CV^2$

E field energy density [J/m³]: $u_E = \frac{1}{2}\kappa\epsilon_0 E^2$

Definition of Dielectric Constant: $C = \kappa C_0$

Eff. Cap. (series) [F]: $\frac{1}{C_{\text{eff}}} = \sum_i \frac{1}{C_i}$

Eff. Cap. (parallel) [F]: $C_{\text{eff}} = \sum_i C_i$

Chapters 25 and 26:

Electric Current [A]: $I = \frac{dq}{dt}$

I from current density [A]: $I = \int \vec{j} \cdot d\vec{A}$

j of uniform current [A/m²]: $|\vec{j}| = \frac{I}{A}$

j for charges in motion [A/m²]: $\vec{j} = nq\vec{v}_d$

Ohm's Law: $\vec{E} = \rho\vec{j}$

Ohm's Law: $\Delta V = IR$ (or often just) $V = IR$

Resistivity and conductivity: $\rho = \frac{1}{\sigma}$

Resistance of a wire [Ω]: $R = \frac{\rho\ell}{A}$

Resistance of an object [Ω]: $R = \int \frac{\rho(x)dx}{A(x)}$

Power in a circuit element [W]:

$P = I\Delta V$ (or often) $P = IV$

Eff. Res. (series) [Ω]: $R_{\text{eff}} = \sum_i R_i$

Eff. Res. (parallel) [Ω]: $\frac{1}{R_{\text{eff}}} = \sum_i \frac{1}{R_i}$

Time constant for an RC -circuit [s]: $\tau = RC$

Charge on a charging capacitor [C]:

$$q(t) = q_{\text{max}}(1 - e^{-t/\tau})$$

Charge on a discharging capacitor [C]:

$$q(t) = q_0 e^{-t/\tau}$$

Current in an RC -circuit [A]: $I(t) = I_0 e^{-t/\tau}$