

1. A capacitor of unknown capacitance is needed in a circuit containing a $100M\Omega$ resistor and a $30V$ battery. This circuit will be used as a timer in part of a larger device. The design of the other device requires the capacitor to charge to 72% of its maximum value in a time of $1.7s$. What value of the capacitance would be needed to achieve this?
2. When fully charged, what maximum charge could the capacitor store?
3. How much energy is stored in the capacitor when it is 72% charged?

4. Suppose that the plates of this capacitor were separated by a distance $d = 1\text{cm}$. If the plates were circular in shape, what would be the radius the capacitor plates? Assume the capacitor is air-filled so that $\kappa = 1$.
5. Suppose that you wired a different air-filled capacitor with capacitance C to a battery with potential difference V . After you wired this capacitor to the battery you realized that the value of the capacitance was too small for what you needed it to do. To change the value of the capacitance you could unwire the entire circuit and start over or realizing that you could increase the capacitance to the value you need by inserting a dielectric between the plates of the capacitor. Which of the following quantities will also increase due to you inserting the dielectric between the plates of the capacitor?
- The electric field between the plates would also increase.
 - The potential difference across the plates would increase.
 - The area of the plates would increase.
 - The charge on the plates would increase.
 - None of the above quantities would increase.

Physics 111 Equation Sheet

Electric Forces, Fields and Potentials

$$\vec{F} = k \frac{Q_1 Q_2}{r^2} \hat{r}$$

$$\vec{E} = \frac{\vec{F}}{q}$$

$$\vec{E}_Q = k \frac{Q}{r^2} \hat{r}$$

$$PE = k \frac{Q_1 Q_2}{r}$$

$$V(r) = k \frac{Q}{r}$$

$$E_x = -\frac{\Delta V}{\Delta x}$$

$$W = -q\Delta V_{f,i}$$

Magnetic Forces and Fields

$$F = qvB\sin\theta$$

$$F = IlB\sin\theta$$

$$\tau = NIAB\sin\theta = \mu B\sin\theta$$

$$PE = -\mu B\cos\theta$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$\mathcal{E}_{induced} = -N \frac{\Delta\phi_B}{\Delta t} = -N \frac{\Delta(BA\cos\theta)}{\Delta t}$$

Constants

$$g = 9.8 \frac{m}{s^2}$$

$$1e = 1.6 \times 10^{-19} C$$

$$k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \frac{Nm^2}{C^2}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{Nm^2}$$

$$1eV = 1.6 \times 10^{-19} J$$

$$\mu_0 = 4\pi \times 10^{-7} \frac{Tm}{A}$$

$$c = 3 \times 10^8 \frac{m}{s}$$

$$h = 6.63 \times 10^{-34} Js$$

$$m_e = 9.11 \times 10^{-31} kg = \frac{0.511 MeV}{c^2}$$

$$m_p = 1.67 \times 10^{-27} kg = \frac{937.1 MeV}{c^2}$$

$$m_n = 1.69 \times 10^{-27} kg = \frac{948.3 MeV}{c^2}$$

$$1amu = 1.66 \times 10^{-27} kg = \frac{931.5 MeV}{c^2}$$

$$N_A = 6.02 \times 10^{23}$$

$$Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

Electric Circuits

$$I = \frac{\Delta Q}{\Delta t}$$

$$V = IR = I \left(\frac{\rho L}{A} \right)$$

$$R_{series} = \sum_{i=1}^N R_i$$

$$\frac{1}{R_{parallel}} = \sum_{i=1}^N \frac{1}{R_i}$$

$$P = IV = I^2 R = \frac{V^2}{R}$$

$$Q = CV = \left(\frac{\kappa \epsilon_0 A}{d} \right) V = (\kappa C_0) V$$

$$PE = \frac{1}{2} QV = \frac{1}{2} CV^2 = \frac{Q^2}{2C}$$

$$Q_{charge}(t) = Q_{max} \left(1 - e^{-\frac{t}{RC}} \right)$$

$$Q_{discharge}(t) = Q_{max} e^{-\frac{t}{RC}}$$

$$C_{parallel} = \sum_{i=1}^N C_i$$

$$\frac{1}{C_{series}} = \sum_{i=1}^N \frac{1}{C_i}$$

Light as a Particle & Relativity

$$E = hf = \frac{hc}{\lambda} = pc$$

$$KE_{max} = hf - \phi = eV_{stop}$$

$$\Delta\lambda = \frac{h}{m_e c} (1 - \cos\phi)$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$p = \gamma mv$$

$$E_{total} = KE + E_{rest} = \gamma mc^2$$

$$E_{total}^2 = p^2 c^2 + m^2 c^4$$

$$E_{rest} = mc^2$$

$$KE = (\gamma - 1)mc^2$$

Geometry

$$Circles C = 2\pi r = \pi D \quad A = \pi r^2$$

$$Triangles A = \frac{1}{2}bh$$

$$Spheres A = 4\pi r^2 \quad V = \frac{4}{3}\pi r^3$$

Light as a Wave

$$c = f\lambda = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$$

$$S(t) = \frac{energy}{time \cdot area} = c\epsilon_0 E^2(t) = c \frac{B^2(t)}{\mu_0}$$

$$I = S_{avg} = \frac{1}{2} c\epsilon_0 E_{max}^2 = c \frac{B_{max}^2}{2\mu_0}$$

$$P = \frac{S}{c} = \frac{Force}{Area}$$

$$S = S_o \cos^2 \theta$$

$$v = \frac{1}{\sqrt{\epsilon \mu}} = \frac{c}{n}$$

$$q_{inc} = q_{refl}$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$M = \frac{h}{h_o} = -\frac{d_i}{d_o}$$

$$M_{total} = \sum_{i=1}^N M_i$$

$$S_{out} = S_{in} e^{-\sum_i \alpha_i n_{pi}}$$

$$HU = \frac{m_u - m_h}{m_p}$$

Nuclear Physics

$$E_{binding} = (Zm_p + Nm_n - m_{rest})c^2$$

$$\frac{\Delta N}{\Delta t} = -\lambda N_o \rightarrow N(t) = N_o e^{-\lambda t}$$

$$A(t) = A_o e^{-\lambda t}$$

$$m(t) = m_o e^{-\lambda t}$$

$$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

Misc. Physics 110 Formulae

$$\vec{F} = \frac{\Delta \vec{p}}{\Delta t} = \frac{\Delta(mv)}{\Delta t} = m\vec{a}$$

$$\vec{F} = -k\vec{y}$$

$$\vec{F}_C = m \frac{v^2}{R} \hat{r}$$

$$W = \Delta KE = \frac{1}{2} m(v_f^2 - v_i^2) = -\Delta PE$$

$$PE_{gravity} = mgy$$

$$PE_{spring} = \frac{1}{2}ky^2$$

$$|\vec{A}| = \sqrt{A_x^2 + A_y^2}$$

$$\phi = \tan^{-1} \left(\frac{A_y}{A_x} \right)$$

$$\vec{v}_f = \vec{v}_i + \vec{a}t$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$\vec{x}_f = \vec{x}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2$$