PHYS1120
Summer 2025

Equations

$F = 1.8\ C + 32$ $\qquad$ $K = C + 273.15$

$Q = mc\Delta T$ $\qquad$ $Q = mL_f$

$Q = mL_v$ $\qquad$ $Q_{\text{gain}} = -Q_{\text{lost}}$

$\Delta L = L\alpha\Delta T$ $\qquad$ $\Delta V = V\beta\Delta T$

$\frac{Q}{t} = \frac{kA(T_2 - T_1)}{d}$ $\qquad$ $\frac{Q}{t} = A\sigma e T^4$

$\lambda_{\max} = \frac{2.898\times10^{-3}}{T}$ $\qquad$ $U = \frac{1}{2}kx^2$

$\omega = \sqrt{\frac{k}{m}}$ $\qquad$ $\omega = \sqrt{\frac{g}{L}}$

$v_0 = A\omega$ $\qquad$ $\omega = 2\pi f$

$f = \frac{1}{T}$ $\qquad$ $c = \lambda f$

$I = \frac{P}{A}$ $\qquad$ $dB = 10\log_{10}\left(\frac{I}{I_0}\right)$

$f_o = f_e\left(\frac{c\pm v_o}{c}\right)$ $\qquad$ $f_o = f_e\left(\frac{c}{c\pm v_e}\right)$

$\left|\vec{F}_e\right| = k\frac{q_1q_2}{r^2}$ $\qquad$ $\left|\vec{E}\right| = k\frac{q}{r^2}$

$\Phi_E = \frac{q_{\text{enc}}}{\epsilon_0}$ $\qquad$ $U = qV$

$V = k\frac{q}{r}$ $\qquad$ $\Delta V = -\vec{E}\cdot\vec{d}$

$Q = CV$ $\qquad$ $C = \kappa\epsilon_0\frac{A}{d}$

$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + ...$ $\qquad$ $C_P = C_1 + C_2 + ...$

$R_S = R_1 + R_2 + ...$ $\qquad$ $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + ...$

$I = \frac{\Delta q}{\Delta t}$ $\qquad$ $I = nqAv_d$

$V = IR$ $\qquad$ $R = \rho\frac{L}{A}$

$R = R_0\left(1 + \alpha\Delta T\right)$ $\qquad$ $V_{\text{bat}} = \mathcal{E} - Ir$

$\sum_i I_i = 0$ $\qquad$ $\sum_i V_i = 0$

$V = \mathcal{E}\left(1 - e^{-t/RC}\right)$ (charging) $V = \mathcal{E}e^{-t/RC}$ (discharging)

$x = x_0 + v_0 t + \frac{1}{2}at^2$ $v^2 = v_0^2 + 2a\left(x - x_0\right)$

$\left|\vec{A}\right|^2 = A_x^2 + A_y^2$ $\theta_A = \tan^{-1}\left(A_y/A_x\right)$

$A = 4\pi r^2$ (sphere) $V = \frac{4}{3}\pi r^3$ (sphere)

$A = \pi r^2$ (circle)

Constants

1 cal = 4.186 J
$g = 9.8$ m s^{-2}
$I_0 = 10^{-12}$ W m^{-2}
$c_s = 343$ m s^{-1} (Speed of sound in air)
$c = 3 \times 10^8$ m s^{-1} (Speed of light)
$k = 9 \times 10^9$ N m^2 C^{-2}
$\epsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
$e = 1.60 \times 10^{-19}$ C
$m_e = 9.11 \times 10^{-31}$ kg
$m_p = 1.67 \times 10^{-27}$ kg
1 eV $= 1.60 \times 10^{-19}$ J

SI prefixes

Name	Symbol	Base 10
Tera	T	10^{12}
Giga	G	10^{9}
Mega	M	10^{6}
Kilo	k	10^{3}
Centi	c	10^{-2}
Milli	m	10^{-3}
Micro	μ	10^{-6}
Nano	n	10^{-9}
Pico	p	10^{-12}
Femto	f	10^{-15}

1. **A winter night in Laramie can reach temperatures as low as -40 °F. You are in your home at a cozy 68 °F.**

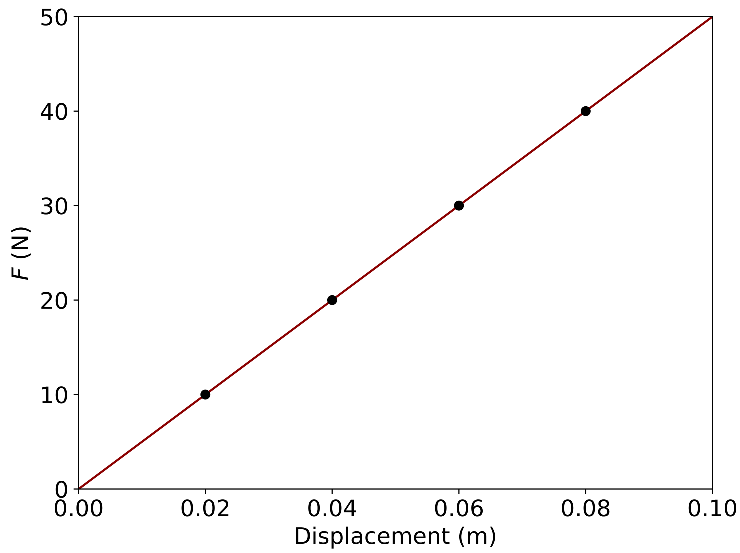
   (a) **Calculate the rate of heat loss through conduction for your home, which you can assume to be a cube with 2 m^2 walls with thickness $d = 0.30$ m and thermal conductivity 2.56 W m^{-1} K^{-1}.**

   (b) **Estimate your monthly heat bill, if you are billed $\$ \ 0.11$ per kilowatt-hour. 1 kWh $= 3.6$ MJ.**

   (c) **Now imagine your power goes out. Calculate the time it would take for the air temperature in your house to drop to 50 °F. Assume a constant rate of heat transfer and a density of air of $1,225$ kg m^{-3} and a specific heat of air of $1,003.5$ J kg^{-1} K.**

2. Below is the applied force as a function of displacement for a spring.

- **(a) Calculate the spring constant.**
- **(b) Calculate the period of oscillations if a 1 kg mass oscillates on this spring.**
- **(c) Calculate the velocity of the 1 kg block as it passes through the equilibrium point if it is initially displaced 2 m from the equilibrium.**
- **(d) What is the position of the block when it is moving at 20 m s^{-1}?**



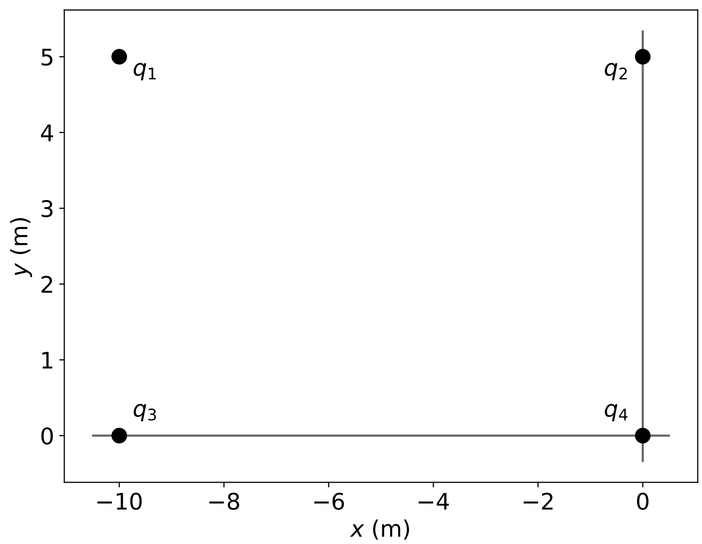
3. Charges are arranged as shown in the figure below. q_1 has charge $3.6\ \mu$C, q_2 has charge $-7.5\ \mu$C, q_3 has charge $9.1\ \mu$C, and q_4 has charge $5\ \mu$C.

(a) Find the electric field (magnitude and direction) at q_4.

(b) Find the electrostatic force (magnitude and direction) acting on q_4.

(c) Find the electric potential at q_4.

(d) Charge q_4 moves through -10 V of potential difference. Assuming it started from rest, find the final speed of q_4 if q_4 has mass $m_4 = 8$ mg.



4. **A -2 C insulating charge with radius $r = 10$ cm is surrounded by a conducting shell of inner radius $r_{\text{inner}} = 25$ cm and outer radius $r_{\text{outer}} = 30$ cm. The conducting shell has a net charge $+4$ C.**

   (a) **Determine the electric field for $r < 10$ cm.**

   (b) **Determine the electric field for $10 < r < 25$ cm.**

   (c) **Determine the electric field for $25 < r < 30$ cm.**

   (d) **Determine the electric field for $r > 30$ cm.**

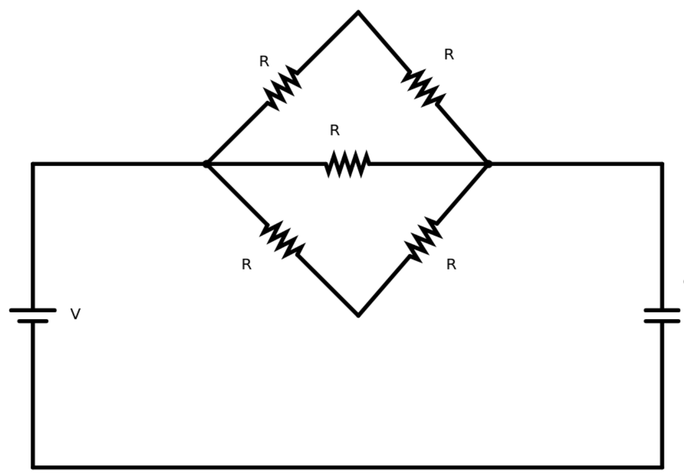
   (e) **Sketch $\left|\vec{E}\right|$ for all regions.**

5. An RC ciruit is shown below. Each resistor has resistance $R = 500$ kΩ, the capacitor has capacitance $5\ \mu$F, and the battery has voltage 20 V.

(a) Find the equivalent resistance.

(b) Find the time constant ($\tau = RC$).

(c) Calculate the time it would take for the capacitor to charge to $80\ \%$ of its full capacity.



Answer Key: **(1a)** 5120 **W**; **(1b)** \$ 405.50; **(1c)** 1.89 **hours**; **(2a)** 500 **N m^{-1}**; **(2b)** 0.281 **s**; **(2c)** 44.7 **m s^{-1}**; **(2d)** 1.79 **m**; **(3a)** 8809.3 **N C^{-1}** @ 17.1 °; **(3b)** 0.0440 **N** @ 17.1 °; **(3c)** -2410 **V**; **(3d)** 0.112 **m s^{-1}**; **(4a)** $-1.798 \times 10^{13}\ r$; **(4b)** $-1.798 \times 10^{10} \frac{1}{r^2}$; **(4c)** 0; **(4d)** $1.798 \times 10^{10} \frac{1}{r^2}$; **(4e)** ...; **(5a)** 250 **kΩ**; **(5b)** 1.25 **s**; **(5c)** 2.01 **s**