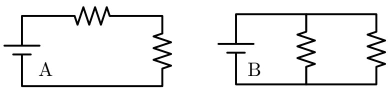
**General Physics II - Spring 2019**
**First Exam**

Show your work. Answers alone get no credit.

$$k = 1.38 \times 10^{-23}\ \mathrm{J/K}$$
$$\sigma = 5.67 \times 10^{-8}\ \mathrm{W/m^2 \cdot K^4}$$
$$\text{water}: c = 4186\ \mathrm{J}/C^{\circ} \cdot \mathrm{kg} \qquad \ell_f = 3.35 \times 10^5\ \mathrm{J/kg}$$
$$k = 9.0 \times 10^9\ \mathrm{N \cdot m^2/C^2}$$

{5} **1** Which circuit will draw more current from the battery?

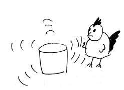



{10} **2** A capacitor with a capacitance of 4 Farads is charged to 7 volts.
**(a)** How much charge is on the capacitor?
**(b)** How much energy is stored in the capacitor?

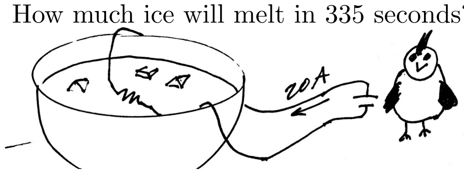
{10} **3** An amount of heat of 2093 Joules is added to 0.5 kg of water.
**(a)** How much does the temperature change?
**(b)** What is the **change** in the average kinetic energy of the water molecules?

{5} **4** You have a chicken coop with a surface area of 6 square meters and walls that are 5cm thick. You plan to heat it with a lightbulb inside. The thermal conductivity of the walls is 0.05W/m·K. The temperature outside the box is 10℃. The chickens have asked for a temperature inside of 25℃. What wattage light bulb should you use to heat the coop?

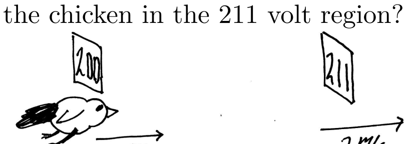
{5} **5** The chickens have developed a micro-fusion-reactor in a steel can. The can is glowing red hot, with a temperature of 1000 Kelvin. The can has a surface area of 0.01 square meters and has an emissivity 0.88183. How much energy is radiated from the can per second?



{10} **6** The chickens are trying to melt the ice in their water bowl. They place an electrical heating element with a resistance of 2.5Ω in the bowl and run a current of 20A through the element. The heat from the element melts the ice. How much ice will melt in 335 seconds?

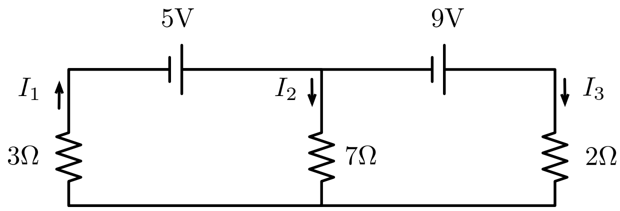



{10} **7** A 3kg chicken with a charge of -6C is drifting through outer space with a speed to $10\frac{\mathrm{m}}{\mathrm{s}}$ as it passes through a region of space with an electric potential of 200 volts. Some time later the chicken passes through a region with an electric potential of 211 volts. What is the speed of the chicken in the 211 volt region?

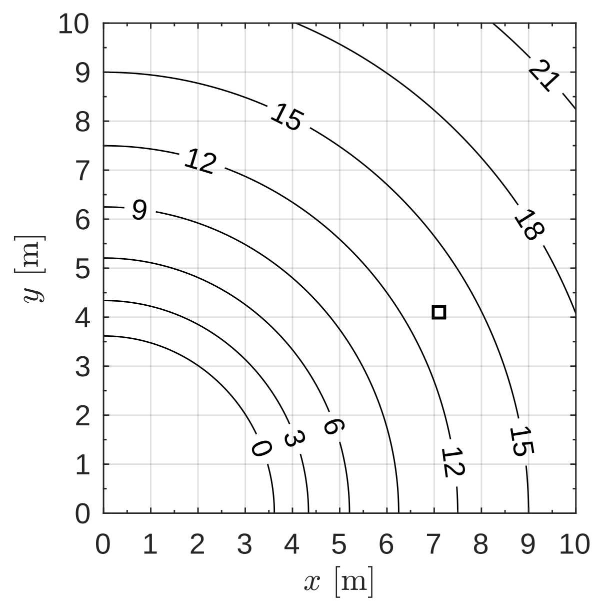



{5} **8** A chicken has charged a rat to -3 Coulombs and is repelling the rat with an electric field that creates a force on the rat of 15 Newtons to the east. What is the magnitude and direction of the electric field?

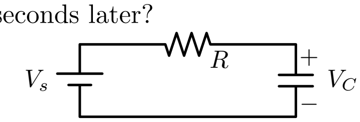
{10} **9** Write equations sufficient to find the three currents.



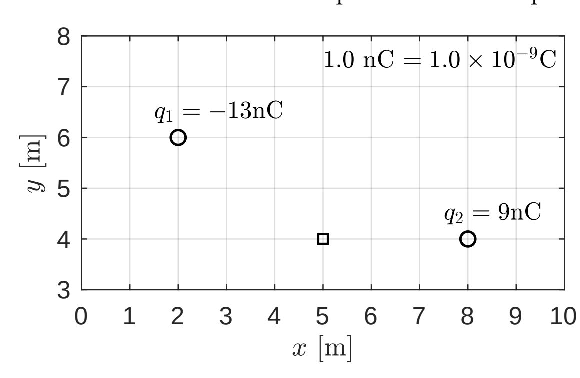

{10} **10** Lines of equal electric potential are show in the graph. The electric potential of each line is labeled in volts.
**(a)** Draw an arrow showing the direction of the electric field at the location of the small square.
**(b)** Compute the magnitude of the electric field at location of the small square.




{10} **11** In the pictured circuit the resistance is 20Ω, the capacitance is 0.3 Farad and $V_s = 12\mathrm{V}$. At time $t = 0$ the voltage on the capacitor is 20V. What will be the voltage 6 seconds later?




{10} **12** Find the electric field at the position of the square.



**Solutions:**

{5} **1** Circuit A has the resistor in series while circuit B has the resistors in parallel. Parallel resistors have less effective resistance so the current will be greater in B.

{10} **2**

**(a)** $Q = CV = (4\Sigma F)(7\text{V}) = 28\text{C}$.
**(b)** $U = \frac{1}{2}QV = \frac{1}{2}CV^2 = 98\text{J}$.

{10} **3**

**(a)** $Q = mc\Delta T$ so
$\Delta T = \frac{Q}{mc} = \frac{2093\text{J}}{(0.5\text{kg})(4186\frac{\text{J}}{C^\circ\cdot\text{kg}})} = 1C^\circ$
**(b)** $\bar{K} = \frac{3}{2}kT$ so
$\Delta\bar{K} = \frac{3}{2}k\Delta T = \frac{3}{2}k(1C^\circ) = 2.07\times10^{-23}\text{J}$.

{5} **4** $P = kA\frac{\Delta T}{\Delta x} = \left(0.05\frac{\text{W}}{\text{m}\cdot C^\circ}\right)(6\text{m}^2)\frac{25^\circ C - 10^\circ C}{(0.05\text{m})}\text{W} = 90\text{W}$.

{5} **5** $P = \sigma\epsilon AT^4$ so
$P = (5.67\times10^{-8})(0.88183)(0.01)(1000)^4\text{W} = 500\text{W}$.

{10} **6** If we let the amount of water melted be $m$ then the amount of heat absorbed is. $Q = m\ell_f$ while the amount of heat emitted by the resistor is $Q = P\Delta t = IV\Delta t = I^2R\Delta t$. Thus $m = \frac{Q}{\ell_f} = \frac{I^2R\Delta t}{\ell_f} = 1.0kg$

{10} **7** $\Delta K + \Delta U = 0 \rightarrow \frac{1}{2}m(v_f^2 - v_i^2) + q(V_f - V_i) = 0$ Thus

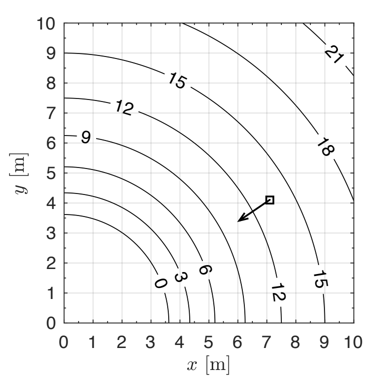
$$v_f = \sqrt{v_i^2 - \frac{2q}{m}(V_f - V_i)}$$
$$= \sqrt{10^2 - \frac{2(-6)}{3}(211-200)}\,\frac{\text{m}}{\text{s}} = 12\frac{\text{m}}{\text{s}}$$

{5} **8** $\vec{E} = \frac{\vec{F}}{q} \rightarrow |E| = \frac{|F|}{|q|} = 5\text{N/C}$, west.

{10} **9**

$$I_1 - I_2 - I_3 = 0$$
$$-(3\Omega)I_1 + 5\text{V} - (7\Omega)I_2 = 0$$
$$(2\Omega)I_3 - 9\text{V} - (7\Omega)I_2 = 0$$

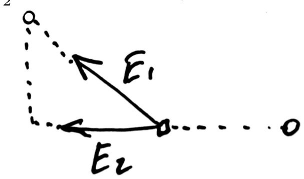
{10} **10** $|E| = \left|\frac{\Delta V}{\Delta r}\right| = \frac{3\text{V}}{1.5\text{m}} = 2.0\text{V/m}$.

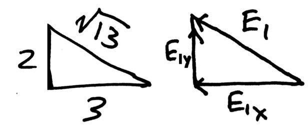



{10} **11** $V_C(t) - V_s = (V_C(0) - V_s)e^{-t/RC}$
so $V_C(6\text{s}) - V_s = (20\text{V} - 12\text{V})e^{-6\text{s}/6\text{s}} = 2.9\text{V}$
so $V_C(6\text{s}) = V_s + 2.9\text{V} = 14.9\text{V}$.

{10} **12** First find magnitudes.

$E_1 = k\frac{|q_1|}{r_1^2} = 9\times10^9\frac{13\times10^{-9}}{3^2+2^2}\frac{\text{N}}{\text{C}} = 9\frac{\text{N}}{\text{C}}$
$E_2 = k\frac{|q_2|}{r_2^2} = 9\times10^9\frac{9\times10^{-9}}{3^2+0^2}\frac{\text{N}}{\text{C}} = 9\frac{\text{N}}{\text{C}}$




$$E_{1x} = -E_1\frac{3}{\sqrt{13}} = -7.49\frac{\text{N}}{\text{C}}$$
$$E_{1y} = +E_1\frac{2}{\sqrt{13}} = 4.99\frac{\text{N}}{\text{C}}$$
$$E_{2x} = -E_2 = -9.00\frac{\text{N}}{\text{C}}$$
$$E_{2y} = 0$$

Thus

$$E_x = E_{1x} + E_{2x} = -16.49\frac{\text{N}}{\text{C}}$$
$$E_y = E_{1y} + E_{2y} = 4.99\frac{\text{N}}{\text{C}}$$

**Instructions:**
Do your work on separate blank paper.
Put this sheet on top and staple them all together.
Use only this exam sheet and a calculator.