Introduction to Physics II — Exam 2
11:30-1:00 Tuesday April 10 2018

You may use a 3"x5" card of notes, both sides. No phones. No calculators. **There is no acceptable reason for your work to look exactly like someone else's work.** "Someone else" includes other people, the textbook, anything on the web, and handed out solutions.

Present clear and complete solutions

Start solutions with definitions (e.g. $\vec{v} \equiv \frac{d\vec{r}}{dt}$), theorems (e.g. Newton's laws), and commonly used equations (e.g. constant acceleration equations).

Any physics/engineering/math major should be able to understand what you did just by reading your solution. A diagram and words usually help. A correct final answer without a reasonably organized justification will earn no credit.

Leave some values and integrals uncalculated.

Do all derivatives.

Do simple integrals: $\int \mathrm{a} z^n dz$, $\int \mathrm{a} e^x dx$, $\int \mathrm{a}(\cos\theta) d\theta$, $\int \mathrm{a}(\sin\phi) d\phi$, and $\int \mathrm{a}\ln(g) dg$.

Leave other integrals unintegrated. Include the limits of integration, move constants out of the integral, and simplify.

$$E_z = \frac{\mathrm{kq}}{2\ell}\int_a^{2b} \frac{z}{(z^2 - \mathrm{b}^2)^{3/2}} dz \qquad \text{is perfect}$$

$$E_z = \int \frac{\mathrm{kq}}{2\ell(z^2 - \mathrm{b}^2)} \frac{z}{\sqrt{(z^2 - \mathrm{b}^2)}} dz \qquad \text{is not}$$

Do simple calculations: (1) multiply, divide, subtract and add integers and (2) sine and cosine of 0, integer multiples of $\frac{\pi}{6}$ (that is $\frac{\pi}{6}, \frac{\pi}{3}, \frac{\pi}{2}, \frac{2\pi}{3}, \ldots$), and integer multiples of $\frac{\pi}{4}$ (that is $\frac{\pi}{4}, \frac{\pi}{2}, \frac{3\pi}{4}, \ldots$)

Leave other calculations uncalculated. Provide an expression that requires a single calculation from your calculator. This means using the correct units.

$$v_f = \left[(10\mathrm{m/s})^2 + (\frac{300\mathrm{N/m}}{0.3\mathrm{kg}})(12\times10^{-2}\mathrm{m})^2\right]^{1/2} \qquad \text{is perfect}$$

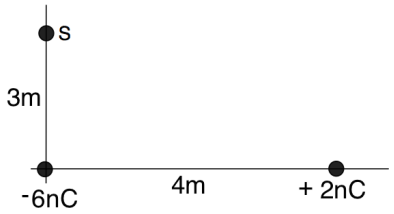
$$\frac{1}{2}(0.3)v_f^2 = \frac{1}{2}(0.3)(10)^2 + \frac{1}{2}(300)(12\mathrm{cm})^2 \qquad \text{is not}$$

Constants

$$k = 1/4\pi\epsilon_0 = 9\times10^9\ \mathrm{N\cdot m^2/C^2} \qquad e = 1.6\times10^{-19}\ \mathrm{C}$$
$$\epsilon_0 = 9\times10^{-12}\ \mathrm{C^2/N\cdot m^2} \qquad m_{\mathrm{proton}} = 1.7\times10^{-27}\mathrm{kg}$$
$$g = 9.8\ \mathrm{m/s^2} \qquad m_{\mathrm{electron}} = 9.1\times10^{-31}\mathrm{kg}$$
$$N_A = 6\times10^{23}\ \mathrm{atoms/mol}$$

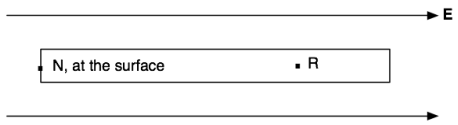
Make-up exams will be arranged if you can provide (1) advance notice (an email or voicemail 15 minutes ahead of time is fine) **and** (2) an approved and documentable excuse. If you cannot do both of these, you cannot make up the exam.

1. A proton starts from rest from very far away. It's attracted to the following charge configuration. Calculate the proton's speed when it arrives at S.



2. The electric potential in a region of space is given by $V(x, y) = A(xy^2 - yx^2)$. Calculate the potential and electric field at position $(2, 2)$.

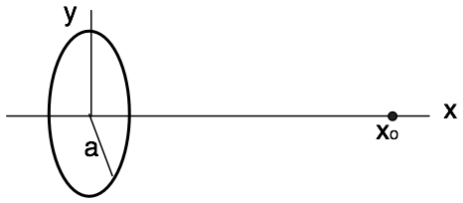
3. A solid rectangular conductor is in a uniform electric field, with a strength of 300 V/m. The potential at N is 150V. Point R is inside and d/4 away from right edge.



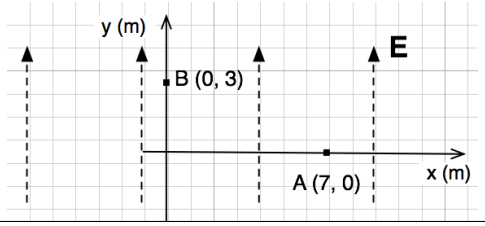
Determine the potential and electric field at R. Support your answer with calculations or a text explanation.

4. Capacitor X requires 70V to store a charge of 50nC. Calculate the voltage required to store 100J on capacitor X.

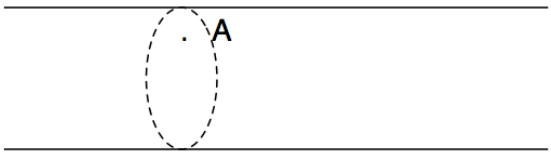
5. A ring lies in the y-z plane and has a uniform charge density of $-\lambda_0$. Determine the potential at x_0.



6. The potential at A is 11 V. The electric field has strength of 13 N/C. Calculate the potential at B.



7. An infinitely long cylinder has a radius of R and has a uniform charge density of ρ_0.

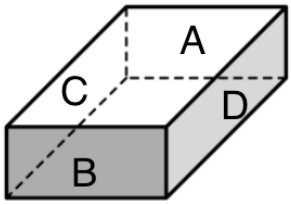


Determine an expression for the electric field at point A, a distance $r < R$ from the center. Include a clear diagram with useful vectors and surfaces.

Answer one of the following

8. (a) You can drive a current I_0 through A&B or C&D. Which pair requires a higher electric field?

Justify your answers with calculations or a text explanation that refers to equations.



(b) Air undergoes dielectric breakdown at a field strength of 3MV/m. Calculate the energy stored in a cube of air, 1cm on a side, when it contains a field of 3MV/m.

9. (a) The capacitance of a parallel plate capacitor is

$$C = \epsilon_0 A/d$$

Derive this equation. Use the definition of capacitance, the electric field between parallel plates, and the relationship between voltage and electric field.

(b) Two capacitors can be placed in series or in parallel. Which configuration will lead to a higher stored charge on the equivalent capacitor? Justify your answer with a calculation or a text explanation that refers to equations.

10. In car Q, the wire connecting the battery to the starter motor has a cross sectional area of 0.21 cm^2, a length of 0.85m, and is made of copper. The wire carries an average of 300A while the engine starts.

In the 0.5 seconds it takes to start the car, calculate the
(a) average distance an e^- travels along the wire.
(b) charge that has passed through a section of wire

electrical properties of copper: charge density $8.5 \times 10^{28} m^{-3}$, resistivity $1.7 \times 10^{-8} \Omega \cdot m$.