Introduction to Physics II — Exam 1
11:30-1:00 Tuesday March 10

You may use a 3"x5" card of notes, both sides. NO PHONES. **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 $\int \mathrm{a}\ln(g)dg$.

Don't do other integrals. Write them out, simplify them, but leave them unevaluated. 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. (2) Calculate 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 $\frac{\pi}{4}, \frac{\pi}{2}, \frac{3\pi}{4}, \ldots$).

Don't do other calculations. Write an expression that requires a single calculation from your calculator. Include all values in the correct units.

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

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

CONSTANTS AND EQUATIONS

$$\epsilon_0 = 9 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2}$$

$$m_{\mathrm{electron}} = 9.1 \times 10^{-31}\mathrm{kg} \quad m_{\mathrm{proton}} = 1.67 \times 10^{-27}\mathrm{kg}$$

$$N_A = 6 \times 10^{23}\ \mathrm{atoms/mol}$$

$$E_{\mathrm{dipole}} = k\frac{2\vec{p}}{r^3}\ \text{along axis} \qquad E_{\mathrm{dipole}} = -k\frac{\vec{p}}{r^3}\ \text{bisecting plane}$$

$$E_{\mathrm{line}} = k\frac{Q}{y = \sqrt{y^2 + (L/2)^2}},\ \text{along} \perp \text{bisector} \qquad E_{\mathrm{inf\ line}} = k\frac{2\lambda}{r}$$

$$E_{\mathrm{ring}} = k\frac{zQ}{(z^2 + R^2)^{3/2}} \qquad E_{\mathrm{disk}} = \frac{\sigma}{2\epsilon_0}\left[1 - \frac{z}{\sqrt{z^2 + R^2}}\right]$$

$$E_{\mathrm{plane}} = \sigma/2\epsilon_0$$

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.

CHAPTERS 21, 22, 23.1-23.2

Coloumb's law, electric field, beginning of Gauss's law

1. For each of the following, (a) provide the symbol, (b) give the SI unit, and (c) identify it as a vector or scalar:

   electric charge, electric force, electric field, linear charge density, surface charge density, permittivity of free space, and electric flux.

   Example. velocity: $\vec{v}$, m/s, vector.

2. From a series of observations of how objects interact (attract, repulse, no effect), determine if an object is charged or neutral.

   If two objects are charged, determine if they have the same or opposite sign.

3. (a) Calculate the net charge on an object.
   (b) Explain how a neutral object becomes positively or negatively charged.
   (c) Calculate the number of excess (or missing) electrons from a charged object.

4. Explain how a neutral insulator can be attracted to a charged object. Include a useful and well-labeled diagram.

   Repeat for a conductor.

5. (a) Identify if a material is an insulator or a conductor, based on how excess charge distributes itself in the material.
   (b) Describe how excess charge is shared between identical conductors that are allowed to touch.

6. Calculate the electrostatic force (a) between a pair of charges and (b) on a single charge from multiple charges.

   If necessary, include forces such as tension, gravity, and springs.

   Include a force diagram drawn to scale.

   Provide either components (F_x, F_y, F_z), or magnitude and direction (F, θ angle from the $+x$ axis)

7. Determine the electric field based the force exerted on a point charge.

8. Determine the electric field from a set point charges.

9. Derive an expression for the electric field from a continuous linear charge distribution, such as a straight line or an arc.

10. Use already-derived-and-given-to-you electric field equations for

    dipoles, lines, rings, sheets, and point charges

    to calculate values of the net electric field from a *combination* of

    dipoles, lines, rings, sheets, and point charges

11. Identify positions where the electric field, or the Coulomb force on a point charge,

    (a) has a component that is zero

    (b) is zero

12. Sketch the electric field using vectors or field lines.

    Interpret the vectors and field lines: determine the magnitude and direction of $\vec{E}$ at any point.

13. Determine an expression for the electric field in limiting cases. For example, $y \gg d$ or $x \ll R$.

14. Determine the force on a point charge in a uniform electric field. Typical point charges: protons, electrons.

    Determine the resulting motion of the point charge. This is can be a 1D or 2D problem, and likely asks for a trajectory, final speed, distance travelled, or distance deflected.

15. Describe what an electric dipole is. Include a sketch.

    Calculate the dipole moment of an electric dipole.

    Describe the motion of an electric dipole in a uniform electric field.

16. Calculate the electric flux for open and closed surfaces. This means

    (a) determining the area vector ($\vec{A}$, $d\vec{A}$), and sketching $\vec{E}$ and the area
    (b) identifying if the electric flux is zero based on the sketch
    (c) a direct calculation of $\vec{E} \cdot \vec{A}$ or $\int \vec{E} \cdot d\vec{A}$
    (d) using Gauss's law

17. Given the electric flux for a closed surface, determine if there's a non-zero net charge inside the surface.

    If there's a non-zero net charge, calculate the net charge.
