Introduction to Physics II — Exam 3
11:30-1:00 Tuesday May 8 2018

You may use a 3"x5" card of notes, both sides, and a calculator.

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 $\int \mathrm{a}\ln(g)dg$.

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 AND EQUATIONS

$$k = 1/4\pi\epsilon_0 = 9\times10^9\ \mathrm{N\cdot m^2/C^2} \qquad e = 1.6\times10^{-19}\ \mathrm{C}$$
$$\epsilon_0 = 9\times10^{-12}\ \mathrm{C^2/N\cdot m^2} \qquad m_{\mathrm{proton}} = 1.7\times10^{-27}\mathrm{kg}$$
$$\mu_0 = 4\pi\times10^{-7}\mathrm{T\cdot m/A} \qquad m_{\mathrm{electron}} = 9.1\times10^{-31}\mathrm{kg}$$
$$g = 9.8\ \mathrm{m/s^2} \qquad N_A = 6\times10^{23}\ \mathrm{atoms/mol}$$

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.

Gauss's law 24.5

Fundamental of circuits 28

Magnetism 29 (skipped 29.3 29.10)

EM induction 30.1-30.5

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

   magnetic field, magnetic force, magnetic flux, the permeability constant, induced current, induced emf.

   For example, force: $\vec{F}$, Newton (N), vector.

2. Use Gauss's law to calculate the electric field of charge distributions such as

   (a) a point charge, spheres and spherical shells,
   (b) infinitely long lines, cylinders and cylindrical shells, and
   (c) an infinite plane of charge.

   Include a diagram of the charge distribution, the electric field, and the Gaussian surface.

3. In a circuit with one battery and several resistors,

   (a) identify which resistors have the same voltage, and which have the same current.

   Calculate

   (b) equivalent resistance
   (c) voltage, current, and power for each resistor
   (d) voltage, current and power supplied by the battery
   (e) If the circuit has a *ground*, determine V at any given point.

4. Analyze any circuit using Kirchoff's rules:

   (a) Identify the currents in the circuit
   (b) Write down a set of equations that completely describes the circuit's behavior. Narrow these down to the minimum required.

5. For RC circuits, calculate

   (a) the time constant. What information does the time constant give you?
   (b) voltage and charge on the capacitor at any time. For example, what's the voltage after 1 time constant? 2 time constants?
   (c) current through the resistor at any time.
   (d) When is the current at a maximum? When is the voltage across the capacitor a maximum?

6. Calculate the magnetic field from

   (a) a line or arc of current
   (b) a loop of current
   (c) infinitely long cylinders and cylindrical shells.

   Use either the Biot-Savart law or Ampere's law, whichever is most appropriate.

7. Using some well known results, calculate $\vec{B}$ from

   (a) an infinitely long straight current carrying wire
   (b) a loop of current
   (c) a magnetic dipole
   (d) a solenoid
   (e) some combination of the above

8. What is a magnetic dipole moment and how is it related to a current loop?

   Use the equation for the field of a magnetic dipole. Where is this equation valid?

9. Calculate the magnetic force on a

   (a) charged particle. It can be positive or negative.
   (b) current carrying wire
   (c) loop of current

10. Explain why a charged particle moves in a circle while in a uniform magnetic field.

    Calculate the radius and frequency of the motion.

11. Explain how an electric motor works. Include a diagram and at least one equation.

12. Derive the equation for the force between two infinitely long, straight current carrying wires

    $$\frac{F}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi r}$$

    Use diagrams and text.

    Explain why parallel currents attract and why antiparallel currents repel.

13. Calculate the motional emf across a conductor.

14. (a) Calculate the induced emf and induced current in a loop of wire in a magnetic field. Provide a magnitude and direction.

    (b) Determine an expression for $\varepsilon_{\text{ind}}(t)$ or $I_{\text{ind}}(t)$