Introduction to Physics II — Exam 2
11:45-12:50 Friday April 17, 2020

Ground rules and Academic honor code

YES: Books, notes, a calculator, and the www.

NO: any interaction with people in real-time. So... no phones, no message boards,

ACADEMIC HONOR CODE: It?s expected that everyone in this class will work together to uphold high standards of integrity. You have many resources you can use on this exam. At the same time, there is no acceptable reason for your work to look exactly like someone else's. "Someone else" includes other people, the textbook, anything on the web, and handed out solutions. **Represent yourself with your work.**

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 are helpful. A correct final value without a reasonably organized justification will earn no credit.

Leave some values and integrals uncalculated

Do all derivatives.

Do these 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 others. Write and simplify them, but leave them unevaluated. Include limits of integration, and move constants out of the integral.

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

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

Do these 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 others. Write an expression that requires a single calculation. Include all values; use the correct units.

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

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

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 flux, electric potential, electric potential difference, electric potential energy, electric potential energy difference, capacitance, current, current density, resistance, emf, resistivity, conductivity.

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

2. Sketch the electric field lines from

   - a point charge, uniformly charged sphere, uniformly charged spherical shell
   - infinitely long charged line, infinitely charged cylinder, infinitely long uniformly charged cylindrical shell
   - an infinite plane of charge

3. Determine an expression for $\vec{E}$ for a(n)

   - point charge, sphere and spherical shell
   - infinitely long line, cylinder and cylindrical shell
   - infinite plane of charge

   Use Gauss's law. Include a clear and labelled diagram of the charge distribution, $\vec{E}$ lines, the Gaussian surface, and $d\vec{A}$.

4. Given a uniform $\vec{E}$, calculate the electric potential difference ΔV between any two points in space.

5. Calculate the change in potential energy ΔU when a charge moves in a potential field. Use this to describe the motion of the charge (initial and final speeds, for example).

6. Calculate V from

   - multiple point charges
   - continuous lines or arcs of charge

7. Calculate U for a configuration of multiple point charges.

   What does it mean to have a positive U? Negative U?

8. Calculate $\vec{E}$ from V.

   Do this from a function for $V(x, y, z)$.
   Do this from a graph (equipotentials or $V(x)$).

   If $V = 0$, then is $\vec{E} = 0$?
   If $\vec{E} = 0$ then is $V = 0$?

9. What is $\vec{E}$ inside the solid part of a conductor? just outside the conductor?

   What is V at every point in a conductor? just outside the conductor?

10. What is a capacitor? What is capacitance C?

    Use the definition of C to calculate the charge or voltage difference for a capacitor.

11. Calculate C for a

    (a) parallel plate capacitor
    (b) spherical capacitor

    Use the given equations; you're not expected to derive them

12. In a circuit with one emf/battery and two or three capacitors,

    (a) identify which capacitors have the same voltage, and which have the same charge.

    Calculate
    (b) equivalent capacitance
    (d) total charge moved by the battery
    (e) total energy stored in the capacitors

13. Calculate

    - current i from current density J (and the reverse)
    - the power of any electrical device

14. For a resistor, calculate

    - the voltage required to drive a current i
    - its resistance R of an object from resistivity ρ and geometry (length, width, height)
    - the power P dissipated by the resistor

15. 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

16. Analyze a circuit using Kirchoff's rules

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

17. For an RC circuit, 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?

    Keep in mind that a capacitor might be charging or discharging. The current equations are the same, but $q(t)$'s are different.