Name:

# Physics 223 Exam 3

Brother Lines

Any Calculator
Equation Sheets Allowed

## Instructions

There are two sections to this exam. One consists of concept questions and one of quantitative problems. Please use the "problem solving process" as much as you can. A copy of the process is attached. You may have one equation sheet that you bring to this exam. You should bring and use a calculator, *but*, remember to get symbolic solutions!

1 If I give you a dielectric material with a dielectric constant of 10, and you place it between the plates of a capacitor, the capacitance will...

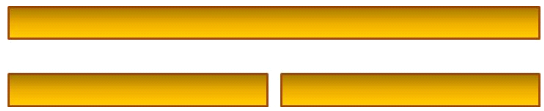
(a) be 10 times larger

(b) be 100 times larger

(c) be 10 times smaller

(d) be 3.123 times the original capacitance

2 If a wire is cut in half, the resistance of one of the remaining pieces will be

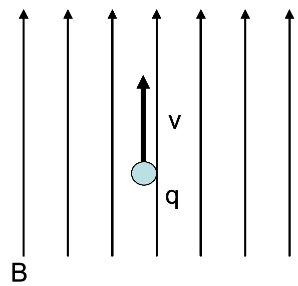


(a) Larger than that of the whole piece

(b) Smaller than that of the whole piece

(c) The same as that of the whole piece

3 A positive charge enters a uniform magnetic field as shown. What is the direction of the magnetic force?



4 A current in a long, straight wire produces a magnetic field. The magnetic field lines:

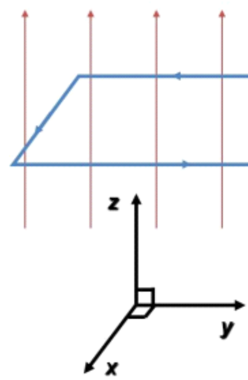
(a)go out from the wire to infinity.

(b)come in from infinity to the wire.

(c)form circles that pass through the wire.

(d)form circles that go around the wire.

5 A rectangular current loop is in a uniform static magnetic field. What is the direction of the net force on the loop?




(a) + x

(b) + y

(c) there is no net force

(d) - x

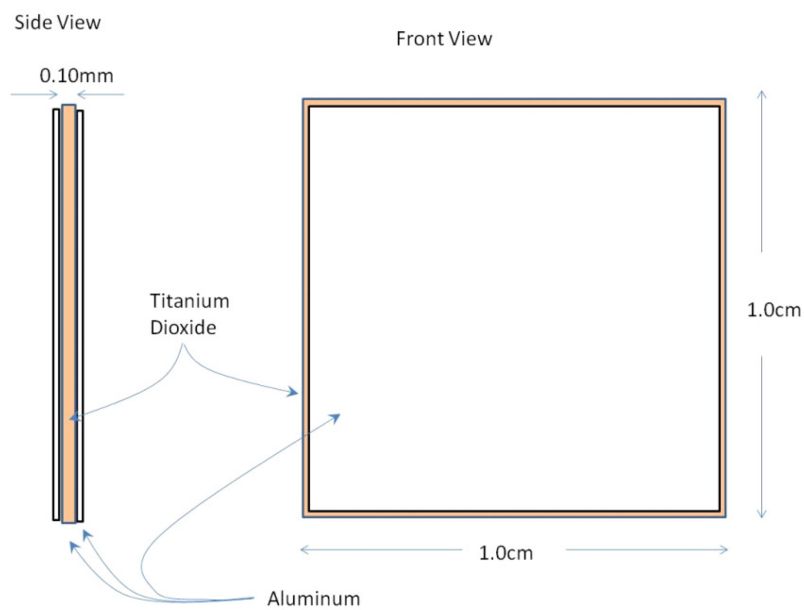
(e) - y

Quantitative Section

For the next set of problems, use our problem solving process.

Exam 3 Conceptual Part Start, Lectures 16-23

6 A parallel plate capacitor is built by taking a piece of titanium dioxide ($\kappa = 173$) that has a thickness of 0.10 mm and a area of 1.00 $\text{cm}^2$. The dielectric is coated on its sides with a thin coating of aluminium. What would the capacitance be?



7 The second linear accelerator (LINAC2) at CERN produces a proton beam. The total current is 150 mA. The proton beam has a roughtly circular cross sectional area that has a 9 mm diameter. What is the current density of the LINAC2 beam?

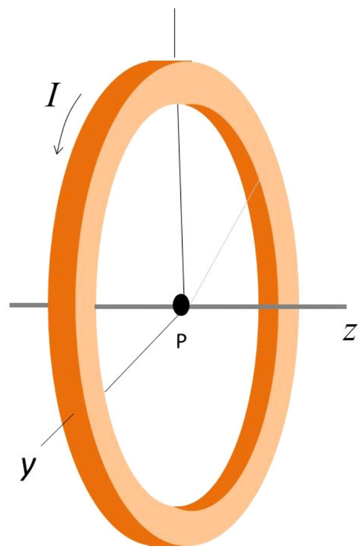
CERN LINAC2

8 A solid cube of silver (density $= 10.5\,\mathrm{g/\,cm^3}$) has a mass of $100.0\,\mathrm{g}$. What is the resistance between opposite faces of the cube? The resistivity of silver is $\rho_R = 1.59 \times 10^{-8}\,\Omega\,\mathrm{m}$.

9 Find the magnetic field due to a round loop with current $I$ right at the center of the loop using the Biot-Savart law

$$\vec{\mathbf{B}} = \frac{\mu_o I}{4\pi} \int \frac{d\vec{\mathbf{s}} \times \hat{\mathbf{r}}}{r^2}$$

You only need a symbolic answer.



10 A single-turn square loop of wire carries a clockwise current of 0.200 A. The sides of the loop are 2.00 cm on each edge. loop is in an external magnetic field of magnitude $5.6549 \times 10^{-2}$ T with the plane of the loop perpendicular to the external magnetic field. Find

a) the force on each side of the loop and

b) the torque acting on the loop.

1.

Some integrals that might be helpful

$$\int \frac{rdr}{\sqrt{r^2+x^2}} = \sqrt{r^2+x^2}$$

$$\int \frac{dx}{\sqrt{x^2+a^2}} = \ln\left(x+\sqrt{a^2+x^2}\right)$$

$$\int \frac{dx}{(x^2 \pm a^2)^{\frac{3}{2}}} = \frac{\pm x}{a^2\sqrt{x^2 \pm a^2}}$$

$$\int \frac{xdx}{(x^2 \pm a^2)^{\frac{3}{2}}} = \frac{-1}{\sqrt{x^2 \pm a^2}}$$

$$\int \frac{dx}{x} = \ln x$$

$$\int \frac{dx}{x^2} = -\frac{1}{x}$$

$$\int_0^{2\pi} \int_0^{\pi} \sin\theta d\theta d\phi = 4\pi$$

$$\int_0^{2\pi} \int_0^{\pi} \int_0^{R} r^2 dr \sin\theta d\theta d\phi = \frac{4}{3}\pi R^3$$

$$\int_0^{2\pi} \int_0^{R} rdrd\phi = \pi R^2$$

Charge and mass of elementary particles

| | |
|---|---|
| Proton Mass | $m_p = 1.6726231 \times 10^{-27}\,\mathrm{kg}$ |
| Neutron Mass | $m_n = 1.6749286 \times 10^{-27}\,\mathrm{kg}$ |
| Electron Mass | $m_e = 9.1093897 \times 10^{-31}\,\mathrm{kg}$ |
| Electron Charge | $q_e = -1.60217733 \times 10^{-19}\,\mathrm{C}$ |
| Proton Charge | $q_p = 1.60217733 \times 10^{-19}\,\mathrm{C}$ |

| | |
|---|---|
| $\alpha$-particle mass[1] | $m_\alpha = 6.64465675(29) \times 10^{-27}\,\mathrm{kg}$ |
| $\alpha$-particle charge | $q_\alpha = 2q_e$ |

Fundamental constants

| | |
|---|---|
| Permittivity of free space | $\epsilon_o = 8.854187817 \times 10^{-12}\,\frac{\mathrm{C}^2}{\mathrm{N\,m}^2}$ |
| Permeability of free space | $\mu_o = 4\pi \times 10^{-7}\,\frac{\mathrm{T\,m}}{\mathrm{A}}$ |
| Coulomb Constant | $K = \frac{1}{4\pi\epsilon_o} = 8.98755 \times 10^9\,\mathrm{N\,m^2\,C^{-2}}$ |
| Gravitational Constant | $G = 6.67259 \times 10^{-11}\,\mathrm{m^3\,kg^{-1}\,s^{-2}}$ |
| Speed of light | $c = 2.99792458 \times 10^8\,\mathrm{m\,s^{-1}}$ |
| Avogadro's Number | $6.0221367 \times 10^{23}\,\mathrm{mol^{-1}}$ |
| Fundamental unit of charge | $q_f = 1.60217733 \times 10^{-19}\,\mathrm{C}$ |

Astronomical numbers

| | |
|---|---|
| Mass of the Earth[2] | $5.9726 \times 10^{24}\,\mathrm{kg}$ |
| Mass of the Moon[3] | $0.07342 \times 10^{24}\,\mathrm{kg}$ |
| Earth-Moon distance (mean)[4] | $384400\,\mathrm{km}$ |
| Mass of the Sun[5] | $1,988,500 \times 10^{24}\,\mathrm{kg}$ |
| Earth-Sun distance[6] | $149.6 \times 10^6\,\mathrm{kg}$ |

Conductivity and resistivity of various metals

| Material | Conductivity $\left(\Omega^{-1}\,\mathrm{m}^{-1}\right)$ | Resistivity $(\Omega\,\mathrm{m})$ | Temp. Coeff. $\left(\mathrm{K}^{-1}\right)$ |
|---|---|---|---|
| Aluminum | $3.5 \times 10^7$ | $2.8 \times 10^{-8}$ | $3.9 \times 10^{-3}$ |
| Copper | $6.0 \times 10^7$ | $1.7 \times 10^{-8}$ | $3.9 \times 10^{-3}$ |
| Gold | $4.1 \times 10^7$ | $2.4 \times 10^{-8}$ | $3.4 \times 10^{-3}$ |
| Iron | $1.0 \times 10^7$ | $9.7 \times 10^{-8}$ | $5.0 \times 10^{-3}$ |
| Silver | $6.2 \times 10^7$ | $1.6 \times 10^{-8}$ | $3.8 \times 10^{-3}$ |
| Tungsten | $1.8 \times 10^7$ | $5.6 \times 10^{-8}$ | $4.5 \times 10^{-3}$ |
| Nichrome | $6.7 \times 10^5$ | $1.5 \times 10^{-6}$ | $0.4 \times 10^{-3}$ |
| Carbon | $2.9 \times 10^4$ | $3.5 \times 10^{-5}$ | $-0.5 \times 10^{-3}$ |

[1] http://physics.nist.gov/cgi-bin/cuu/Value?mal
[2] http://nssdc.gsfc.nasa.gov/planetary/factsheet/earthfact.html
[3] http://nssdc.gsfc.nasa.gov/planetary/factsheet/moonfact.html
[4] http://solarsystem.nasa.gov/planets/profile.cfm?Display=Facts&Object=Moon
[5] http://nssdc.gsfc.nasa.gov/planetary/factsheet/sunfact.html
[6] http://nssdc.gsfc.nasa.gov/planetary/factsheet/index.html

## Problem Solving Process

| Process Step | Purpose | Value if Present | Value if Absent |
|---|---|---|---|
| Label the problem with chapter and problem number | This is essential if I am to figure out what problem to grade | 0 | 0 to -25 |
| **Restate the problem in your own words.** One line may do! List any assumptions you are making. You may wish to classify the problem in your problem statement | Most major mistakes come from misinterpreting the problem. This step asks you to slow down and determine what the problem really is asking | 1 | -1 |
| **Identify the type of problem**. Pick a strategy, is it a Newton's Second Law problem? Is it a rotational problem with constant rotational acceleration? | By identifying the type of problem it is, you are more likely to be able to find the right equations to get started and to successfully complete the problem. The idea is to pause and see what approach will likely be involved in forming the solution. This is not as hard as it sounds. If the word "force" appears, you can reasonably assume Newton's Second Law will be involved, for example. | 2 | -2 |
| **Draw a picture**, label items, define coordinate systems, etc. *This picture should be a visual restatement of the problem. View this as a graphical restatement of the problem.* | Many mistakes happen because we do not have a clear picture of the problem. This step may save hours of grief. Also, many physics problems will have different symbolic answers because of the freedom to choose coordinate systems, etc. Drawing a diagram gives the reader the ability to understand your vision of the problem. | 5 | -5 |
| **Define variables** used, Identify known and unknown quantities | Choose reasonable names for physical quantities, and let me know what they are. Don't forget to include units. | 2 | -2 |
| **List basic equations** that apply to the problem | This step gives you a firm starting place. | 2 | -2 |
| **Solve the problem algebraically** starting from the basic equations, | This is the heart of the solution. The symbolic answer tells you the relationships between physical quantities. | 10 | -10 |
| **Determine numerical answer** | The specific numerical answer is not the point of doing the problem in this class, but is a great indicator that you have succeeded in understanding the physics. | 1 | -1 |
| **Check units.** If you have not done the algebra on the units earlier, do it here. | Many mistakes are evident in a units analysis. It is a good habit to always check units. | 1 | -1 |
| **Determine if the numerical answer is reasonable**. Indicate if you are comfortable with the result, if you have little experience with the result and can't tell if it is reasonable, or if it is not reasonable, but you don't know why (or else you would fix it). | From your understanding of the physics, state whether the answer is reasonable. For example, if you are calculating the mass of a ping pong ball, and get an answer that is many times the mass of the earth, you should note that there may be a problem even if you do not know where you went wrong. | 1 | -1 to -25 |
| **Total Possible** | | **25** | |