# Final Exam (May 5, 1999)

Please read the problems carefully and answer them in the space provided. Use the back, if necessary. Be sure to put your name on each sheet. Partial credit given unless marked otherwise. You will find a higher percentage of "no partial credit" problems than you've seen on the other exams due to the need to expedite grading.

Problem (1) - 10 pts - no partial credit:

Select the correct answer to the problem below.

Two identical resistors are connected across a constant potential difference line. In configuration (I) they are connected in parallel. In configuration (II) they are connected in series. The power dissipated in configuration (I) as compared to configuration (II) is (circle the correct answer):

(a) Twice as much
(b) Half as much
(c) Four times as much
(d) One-quarter as much
(e) Eight times as much
(f) The same
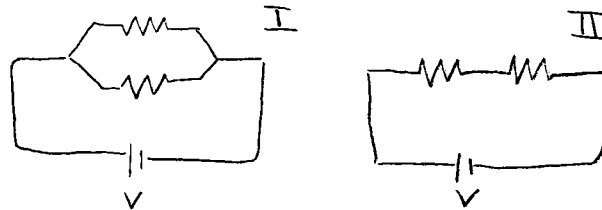
Problem(2) - 10 pts:

You've isolated a structure within a cell that you believe holds the key to some particularly virulent illness that ravages slugs in southeastern Namibia. The last piece of data you need to confirm your fabulous discovery is an image of this structure. You know the structure is approximately 200 nm in size. Would you turn to visible light microscopy or electron microscopy to obtain this image? Briefly tell me why?

For your information: the wavelength of visible light ranges from 400-700 nm and the wavelength of the electrons used in an electron microscope ranges from 0.1 to 0.01 nm.
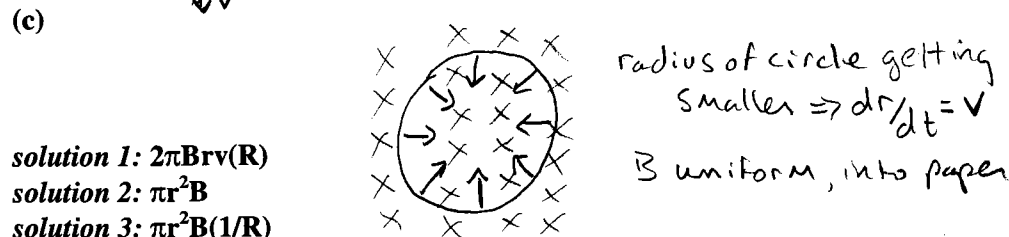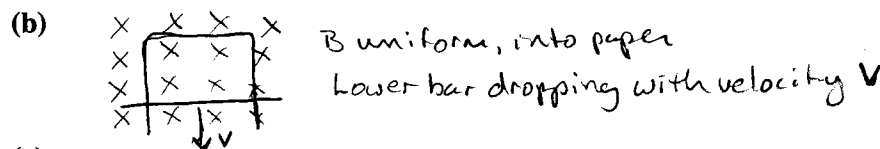
Problem (3) - 10 pts:

For the circuit shown below, find the currents in the separate segments. Label the diagram with your answers (both magnitude and direction). Show your work.
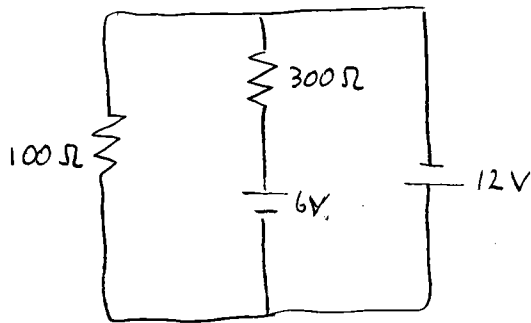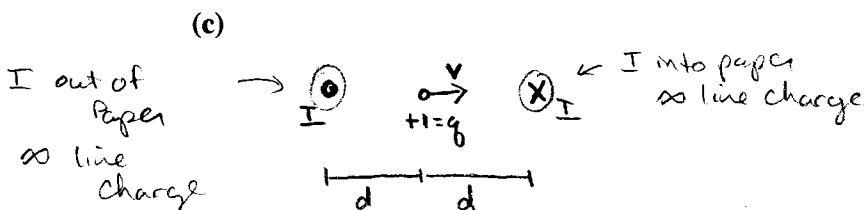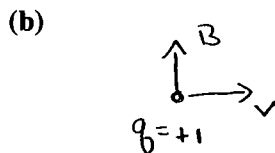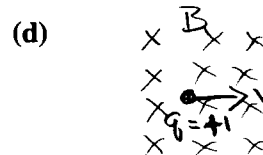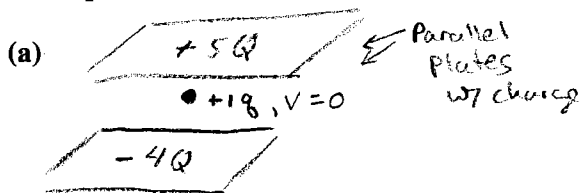
Problem (4) - 10 pts - no partial credit:

Magnetic induction - Below you will find three sketches of conducting wire loops in magnetic fields. In each case, a change is causing the magnetic flux through the loop to change. Draw on the diagram the direction of the current induced in the loop due to the change. For part (c), in addition to marking the direction of the induced current on the loop, circle the correct solution for the magnitude of the induced current.

(a)

Loop moving down w/ velocity v

(b)

B uniform, into paper
Lower bar dropping with velocity v

(c)

radius of circle getting smaller ⟹ $dr/dt = v$

B uniform, into paper

solution 1: $2\pi Brv(R)$
solution 2: $\pi r^2 B$
solution 3: $\pi r^2 B(1/R)$
solution 4: $2\pi Brv(1/R)$
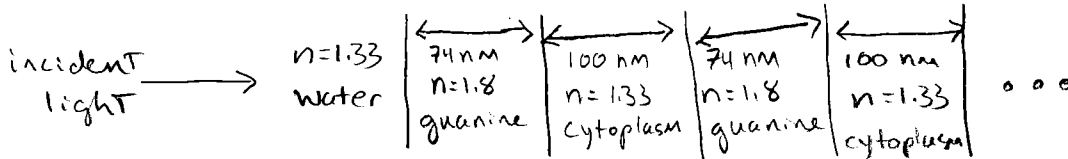*solution 5:* $\pi r^2 Bv(1/R)$

Problem (5) - 10 pts - no partial credit:

State the direction of the force on the particle for the configurations shown. Your choices are "Up", "Down", "Right", "Left", "into the paper", "out of the paper", and "no force".

(a)

Parallel plates w/ charge

(d)

(b)

(e)

(c)

I out of paper
∞ line charge

I into paper
∞ line charge

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Problem (6) - 10 pts:

Many fish, such as herring, have a brilliant silvery appearance in the ocean. This is due to platelets that are attached to the surfaces of the fish. Each platelet is made up of several alternating layers of crystalline guanine (n=1.8) and cytoplasm (n=1.33). The outer layer is guanine. In a typical platelet, guanine layers are 74 nm thick on average, while the cytoplasm layers are 100 nm thick. See the drawing below.

incident
light →

n=1.33
water

| 74 nm
n=1.8
guanine | 100 nm
n= 1.33
cytoplasm | 74 nm
n=1.8
guanine | 100 nm
n=1.33
cytoplasm | o o o

(a) For the typical platelet (shown in the diagram), determine the visible (400-700 nm) wavelength(s) that are most strongly reflected?

The surface of a herring has many platelets, side by side, with varying layer thicknesses so that all visible wavelengths are reflected strongly ... thus, the silver color! ... Is that cool, or what? And to think you took this course just to satisfy a requirement for your major.

(b) The color most strongly reflected by a platelet depends on the angle at which it is viewed. *Briefly* explain why this is so.

Problem (7) - 10 pts:

Jimmy thinks Lois Lane is one wonderful lady. He'd love nothing better than to have her over for dinner. However, the scuttlebutt in the newsroom is that Lois is Superman's main squeeze and Jimmy has no desire to face a jealous Superman! But Jimmy is a pretty bright guy. He takes nuclear physics courses in night school. The other day he stole a pocketful of kryptonite from the laboratory. Everyone knows that the radioactive decay of kryptonite makes Superman powerless when he is nearby. So Jimmy figures he can keep keep the kryptonite in his pocket and hit on Lois at will, provided she thinks it's a good idea.

Kryptonite is an unusual element. It decays with a half life of two years (6×10^7 s) by emitting an alpha particle. The mechanism of kryptonite's effect on Superman is not understood. However, it is known that any kryptonite sample with an activity (also known as decay rate) of 10,000 decays/s or greater causes Superman to lose his powers instantaneously if he is within 10-20 meters.

(a) Jimmy stole a sample of kryptonite oxide containing 2×10^{12} kryptonite nuclei. How long after the theft can Jimmy court Lois before Superman squashes him with his superpowers? Show your work.

(b) Given the location of the sample (in his pocket), is the Kryptonite more or less damaging to Jimmy's body than a gamma source of comparable activity? Why?

As it turns out, Jimmy's plan goes awry because Superman also studied physics. Jimmy gets no further than lighting the candles at dinner when Superman zips in through one open window and out another at a very high velocity. He grabs Lois as he flies by and takes her away to have dinner at his place.

(c) How fast must Superman fly as he passes through Jimmy's apartment in order to be able to nab Lois without losing his powers? Assume the dinner occurred such a short time after Jimmy's theft that Jimmy measured the activity of the sample to be virtually unchanged. Show your work.

Problem(8) - 10 pts:

Consider the system of two lenses shown below. Light from the object first passes through the left lens (converging) and then the right lens (converging). Fill in the table showing your work below. All positions should refer to the absolute scale shown.

Lens	Object position	Image position	Size of image	Image Upright/inverted
Left lens	10cm			
Right lens				

Height = 1cm

0 cm   10cm   20 cm   30 cm   40 cm   50 cm   60 cm

lens 1
F = +5cm

lens 2
F = +5cm
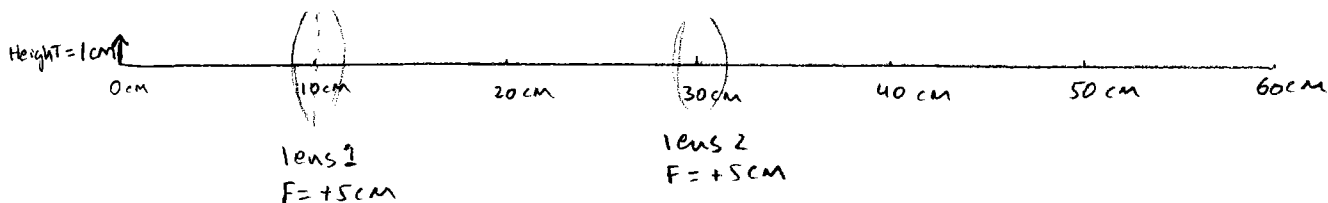
Problem(9)- 10 pts - no partial credit:

A solid, conducting sphere of radius a is concentric with a hollow conducting shell of radius b, where b>a. If the solid sphere has a charge +Q and the hollow sphere has a charge -Q, select the correct solution for the magnitude of the electric field for each of the regions indicated.

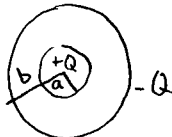*Solution 1:* $E = kQ/r^2$
Solution 2: $E = 2kQ/r^2$
Solution 3: $E = kQ/a^2$
Solution 4: $E = 0$
Solution 5: $E = kQ/(b-a)^2$
Solution 6: $E = kQ/b^2$
Solution 7: $E = 2kQ/b^2$

(a) 3pts. - Write down the solution valid for r<a.

(b) 4 pts - Write down the solution valid for a<r<b.

(c) 3 pts - Write down the solution valid for r>b.

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Problem(10) - 10 pts:

Niels Bohr is one of your high school chums. Anxious to not be shown up by him at the next high school reunion, you decide to extend his quantization hypothesis ($L=mvr=nh/2\pi$) from the force of electromagnetism to gravity. Derive an expression for the allowed orbital radii of a "particle" of mass m orbiting a much more massive "particle" of mass M. --- "Much more massive" means you can neglect the motion of the more massive particle. --- Use this to calculate the orbital radius of the ground state of a hydrogen atom assuming the proton and electron to each be electrically neutral and the only force attracting them is the force of gravity.

$M_p=1.7\times10^{-27}$ kg , $M_e=9.1\times10^{-31}$ kg , $h=6.62\times10^{-34}$ Js, $G=6.7\times10^{-11}$ Nm^2/kg^2,