1a) (10 Points) Muons are unstable particles which--if at rest--decay after a time of only 2.0×10^{-6}s. Suppose a muon is created at an altitude of 8km above the surface of the earth. How fast must it go if it is to reach the surface of the earth before decaying. (I.e., find the speed such that the muon, when traveling close to the speed of light, will survive the 8km trip.)
(Hint: make sure that the speed is less than the speed of light.)

1b) (10 Points) An astronaut circles the earth for 25 hours (*convert*) at a speed of 10km/s. What was the time dilation factor of his clock relative to the earth? How many seconds did his clock fall behind during the entire trip?

2) (20 Points) A thin oil slick of index of refraction n=1.3 floats on water. When a beam of white light strikes this film vertically, the only colors enhanced in the reflected beam seen in are are λ_1=6000A and λ_2=4000A. From this, deduce the thickness of the oil slick.

3) (20 Points) A converging lens of f=25cm is 60cm from a converging mirror of f=20cm. A light bulb is 80cm from the lens.
a) (5 points) Sketch a figure of what a converging lens and mirror look like.
b) (5 points) Where does the lens form an image of the light bulb?
c) (5 points) Where does the mirror form an image of the this image?
d) (5 points) Sketch a ray diagram showing the approximate positions of each image.

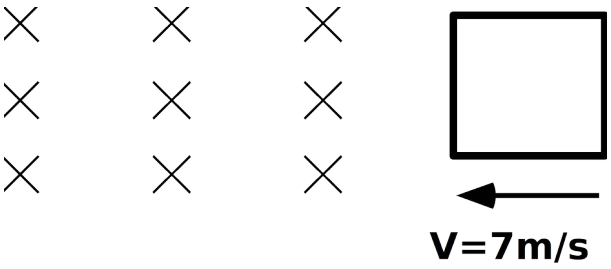
4) (20 Points) The AM radio band spans the frequencies from $\mathbf{f_1=540kHz}$ to $\mathbf{f_2=1600kHz}$. You want to build a radio that covers the entire AM range. You are given a $\mathbf{R=10^2\Omega}$ resistor, a $\mathbf{L=10^{-2}H}$ inductor to build an RLC circuit. Assume the EMF of the signal is **100V**.
(Hint: Think resonant frequency, and find C_{max} and C_{min}.
Remember: 1Hz=2π radians.)
a) (5 points) Find the range of capacitance C necessary to cover the AM range of frequencies.

b) (5 points) When the circuit is tuned to 540kHz, sketch the maximum current $\mathbf{I_{max}}$ as a function of frequency. Indicate the resonant frequency on the graph.

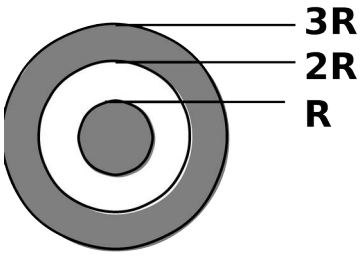
c) (5 points) When the circuit is tuned to 540kHz, the capacitor should be adjusted to C_{max}. Compute the total impedance, $\mathbf{Z_{TOT}}$, and the maximum current of the circuit, $\mathbf{I_{max}}$.

d) (5 points) When the capacitor should be adjusted to C_{max}, (i.e., the circuit is tuned to 540kHz), compute the total impedance, $\mathbf{Z_{TOT}}$, and the maximum current of the circuit, $\mathbf{I_{max}}$, if the incoming frequency is 560kHz.
(Hint: use $C=C_{max}$, but use f=560kHz.)

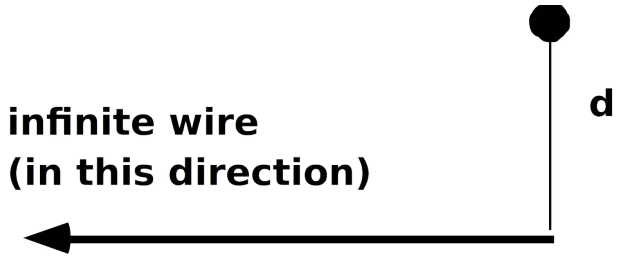
5) (20 Points) A square loop of wire 1 meter on a side and moving with a velocity of 7m/s enters a region of magnetic field 5 meters long with B=3T.
a) (10 Points) Sketch the EMF as a function of time. Be sure to indicate the direction of the induced current when the loop i) enters, ii) is inside, and iii) leaves the magnetic field.
b) (10 Points) Compute the EMF as a function of time when the loop i) enters, ii) is inside, and iii) leaves the magnetic field.



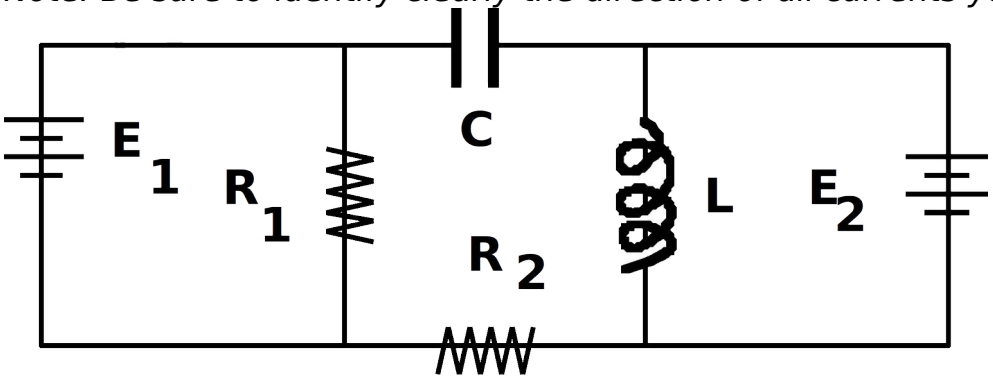
6) (20 Points) A coaxial wire carries a current I_1 in the center wire (radius R), and current I_2 in the outer cylindrical shell inner radius 2R, outer radius 3R. (Note, I_1 does not cancel I_2.)
Find the magnetic field for: i) r<R, ii) R<r<2R, iii) 2R<r<3R, iv) 3R<r.



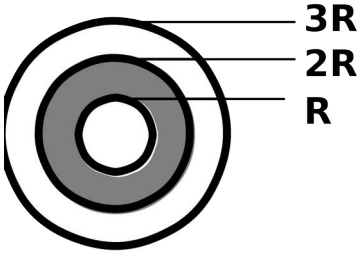
7) (20 Points) Starting from the Bio-Savart Law, find the magnetic field (magnitude and direction) for a semi-infinite wire carrying a current I, if we are a distance d from the end of the wire as shown in the figure.
(Note: I will not accept any magic formulas. I want to see you set up the proper integral. The setup is the main object here.)



8) (20 Points) Given the circuit shown, write down a set of equations (both Kirchoff's and current conservation) which can be used to find all the currents in the branches of the circuit.
Do not try to solve the equations.
(Do not be afraid of the Capacitor or Inductor.)
Note: Be sure to identify clearly the direction of all currents you define.



9) (20 Points) A metallic sphere of radius R is surrounded by a concentric dielectric shell of inner radius R, outer radius 2R. The dielectric constant of this shell is κ. This is surrounded by a concentric thin metallic shell of radius 3R. What is the capacitance of this contraption.



10) (20 Points) An insulating sphere of radius R carries a charge +Q. This is surrounded by a concentric shell of inner radius 2R and outer radius 3R, also with a charge +Q. (Note, the charges do not cancel.)
a) (10 points) Compute the electric field at all points in space.
b) (10 points) Plot the electric field and the potential as a function of distance, indicating each region. **Be sure the indicate the proper r-dependence of the potential in each region.**