Physics 1010 Homework 11 (23+ pts)

Part 1: due Mon Dec 10 midnight: 8 pts on lasers
Part 2: due Wed Dec 12 midnight: 15+ pts on REVIEW!!!

Part 1: Lasers

1.) (2pts) **HW 10 Correction.** Each week you should review both your answers and the answer key for the previous week's homework. Often (including this week) you will get to submit one homework correction. Select one problem for which you had the wrong answer. In the text box below, 1) identify the question number you are correcting, 2) state (copy) your original wrong answer, 3) explain where your original reasoning was incorrect, the correct reasoning for the problem, and how it leads to the right answer. If you got all the answers correct!!! bling bling... state which was your favorite / most useful homework problem, and why.

2.) (1pt) The Sun provides most of the energy that makes life on earth possible. The Sun's surface reaches a temperature of about 5800 C and emits sunlight which travels the 150,000,000 km to Earth at a speed of 3*10^8 m/sec in about 8 minutes. Electromagnetic radiation is emitted when charged particles accelerate. Sunlight is a blend of electromagnetic waves of different wavelengths.

Check out the blackbody spectrum simulation:
http://phet.colorado.edu/en/simulation/blackbody-spectrum

Describe the distribution of electromagnetic radiation emitted from the sun (what wavelengths are emitted? is it all visible light? is there more blue light than red light?).

3.) (1pt) Why do you get a distribution of wavelengths instead of just one wavelength?

4.) (0.5 pt) In discharge lamps like we used in class, free electrons are accelerated along the axis of the lamp, exciting atoms as they smash into them. The light emitted from a neon discharge lamp appears red, because

(a) the free electrons in the discharge are accelerated with exactly the right amount of energy so it produces red photons.
(b) the inside of the lamp is coated with phosphors that emit red light.
(c) the excited electrons in the neon atoms most often transition between two energy levels whose energy spacing corresponds to that of a red photon.
(d) the neon lamp runs at a cooler temperature than an incandescent light bulb, and cooler objects emit redder light.

5.) (0.5 pt) T/F: The colors of different discharge lamps are different because the molecules are moving differently. But if they were not moving around they would all look the same color.

6.) (1pt) In making a laser, what are three critical conditions in order to make it work?

7.) (1pt) What are three (relatively) unique features of laser light (as compared to a regular light bulb)?

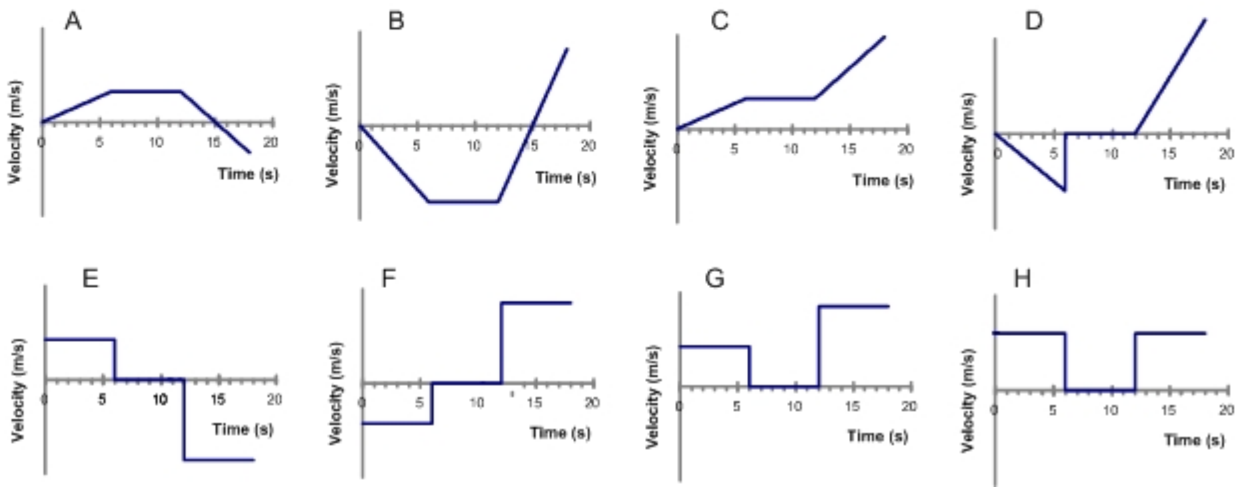
8.) (1pt) Pick one of those features that makes the laser unique … what does this allow you to do that a light bulb wouldn't be able to do?

Part 2: REVIEW!!

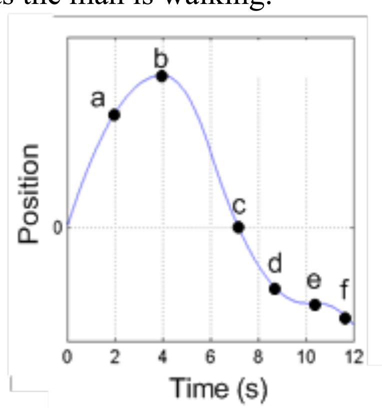
1.) In class, we looked at how human motions could be represented on *position versus time* and *velocity versus time* graphs by using a motion detector to collect data. Use Moving Man to simulate the following scenario:

A man starts at the origin, walks towards the house (to the right) slowly and steadily for 6 seconds, then stands still for 6 seconds, and then turns around and walks towards the tree steadily about twice as fast for 6 seconds.

Which of the following *velocity versus time* graphs conveys this type of motion:



2.) The motion of a walking man is recorded on the *position vs time* graph below. Use the Moving Man Applet in the "Walk" mode to reproduce this *position vs time* graph by adjusting the velocity slider as the man is walking.



What does point b represent in terms of velocity and motion?

3.) At which point(s) is the velocity greater (note speed and sign!) than at point (b)?

4.) At which point has the person shown the greatest displacement from the origin?

5.) At which point has the person traveled the longest distance overall?

6.) Are the following objects accelerating (yes/no)?

- **a)** A car driving in a straight line at a steady 100 mph
- **b)** A ball that I have thrown vertically upwards from my hand, at the top of its trajectory
- **c)** A ball that I have thrown vertically upwards. Consider only the instant after it leaves my hand
- **d)** A car crashing into a tree
- **e)** A ball in a circular track traveling at constant speed
- **f)** A rocket ship after lift-off, where it is traveling in a straight line at constant speed

Questions 7-10: Stopping distance:
The Mars rover is moving along at a speed of 2 m/s (it knows how to motor!) in a straight line, and in its sights it spies a rock formation up ahead in its path, and it decides to stop precisely at the rock to investigate.

7.) How many of the following do you need (in addition to its velocity) to figure out whether it will stop in time at the right place:

distance ($x - x_0$); time; acceleration (braking)

8.) If the rover doesn't brake, how long will it take to hit the rock, if the rock is 50 meters away?

9.) If the rover starts to decelerate (brake) at $a = -0.2 m/s^2$, how long will it take to stop?

10.) Will the rover be able to stop soon enough to look at the rocks? (Why or why not?)

Questions 11-15: I slide a heavy box (200kg) across the carpet at a steady velocity by pushing horizontally. My speed is a constant 0.2m/s, and I'm moving to the right.

11.) Which of the force arrows match which of the following forces? *(Note: D2L might list the forces in a different order than the order shown here!!! Be careful!)*

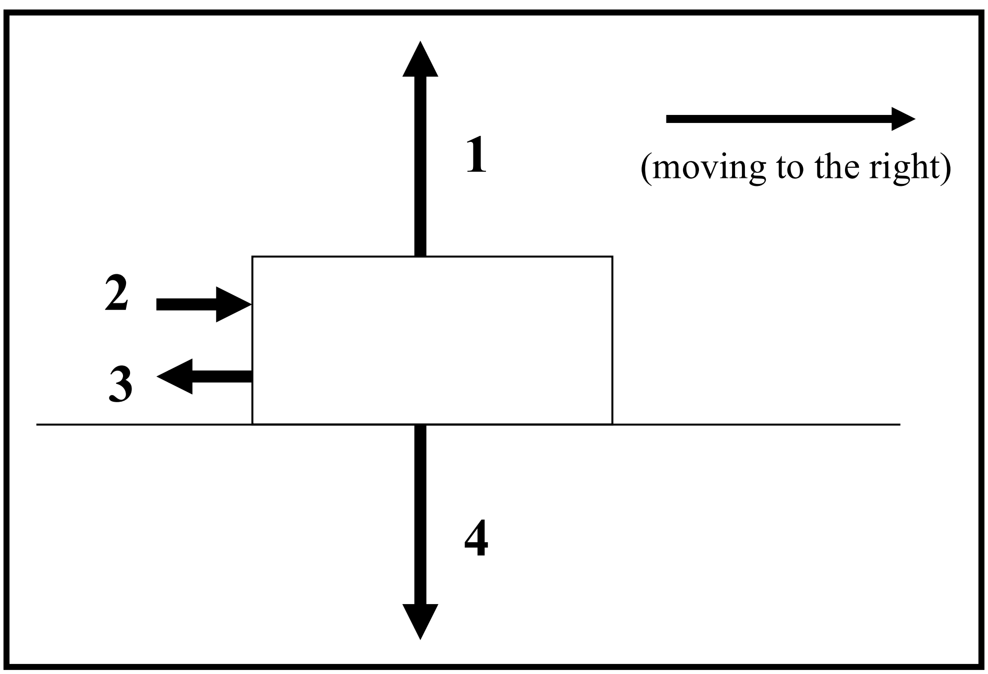
_____ gravitational force

_____ frictional force

_____ weight of the box

_____ pushing force

_____ normal force



12.) What is the net force on the box?

13.) Approximately what is the size of the friction force in N?

(Remember from class – if you're sliding a block on a smooth-ish floor, then the force of friction is about 0.3 x weight.)

14.) Therefore approximately how hard must I be pushing (horizontally) in N?

15.) How would the friction force change if my dog jumped on top of the box as I was pushing? (Would it increase/decrease/stay the same? Use physics principles to justify your answer.)

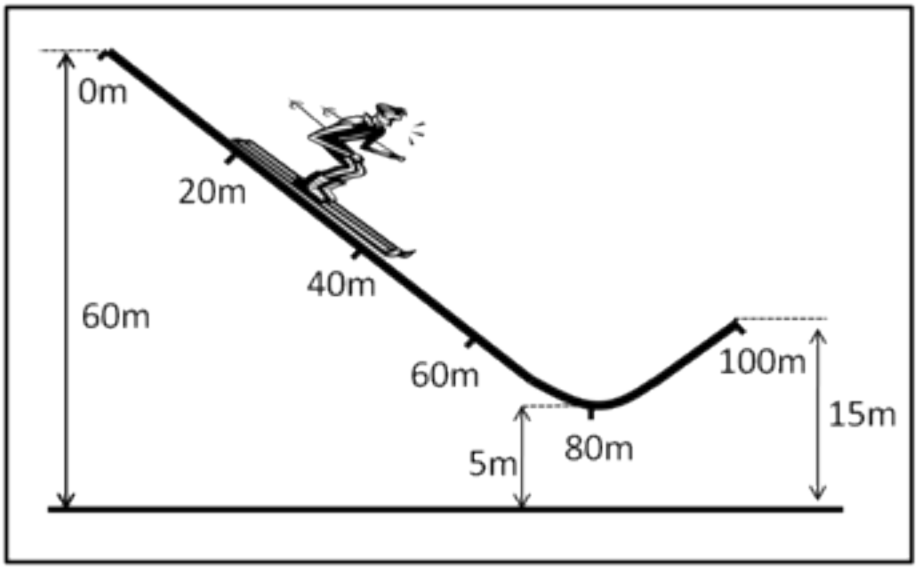
16.) You decide to string lights up on the lift. You have 20 light bulbs that each are rated at 200 Watts, for a total of 4000 W of light. Each hour these are on, how many Joules of energy are used:

a. 240 Joules
b. 400 Joules
c. 4000 Joules
d. 240,000 Joules
e. 14,400,000 Joules

17.) Let's say you had to produce that much energy on a stationary bicycle. How long would you have to ride? Assume 150 Watts steady state on a bike (in good shape).

The Ski Jump: For questions 18-26, consider a skier heading down the ski jump shown below. The distances along the ramp are shown. He starts from rest at a height of 60m above the ground, is 5m above the ground at the lowest point and leaves the ramp at a vertical height of 15m. Assume there is zero friction and air resistance.

NOTE: remember that we only care about *differences* in height for potential energy, not *absolute* height.



18.) The ski jumper has maximum KE at the start of the run (T/F)

19.) The ski jumper has minimum GPE at the takeoff point (T/F)

20.) 'GPE + KE = constant' is true for the skier's motion along the ramp (T/F)

21.) What form of energy is maximized at the 80m mark:
KE, GPE, Thermal, none

22.) How does the net force acting on the skier at the 20m mark compare with the net force on the skier at the 40m mark:
smaller, bigger, same

23.) If we halve the height of the downhill part of the ramp, the speed of the skier at the 80m mark will be:
the same, half, one quarter, one eighth, some other number

24.) The KE of the skier decreases between 80 and 100m (T/F)

25.) Imagine (for this question only) that we changed the shape of the run by adding a large smooth bump around the 20m mark.
True or false: When the skier hits the take off point after traveling down this new ramp, he will be traveling slower than when he took off from the original bump-less ramp.

26.) Assuming that the force of friction is negligible, what is the KE of a 100kg skier at the 80m mark? What is her velocity? Show your working. [Hint: is there any work being done? Another hint: how much did the height change?]

27.) What happens to water that flows out of a pipe at constant pressure (or constant flow rate), and then enters a restriction in the pipe (e.g. goes from a fat pipe to a thin pipe, but the pressure in the fat part of the pipe stays the same):

a) it stays at the same pressure and velocity
b) the velocity goes up and the pressure goes down
c) the velocity goes down and the pressure goes up
d) the velocity goes up and the pressure goes up
e) the velocity goes down and the pressure goes down

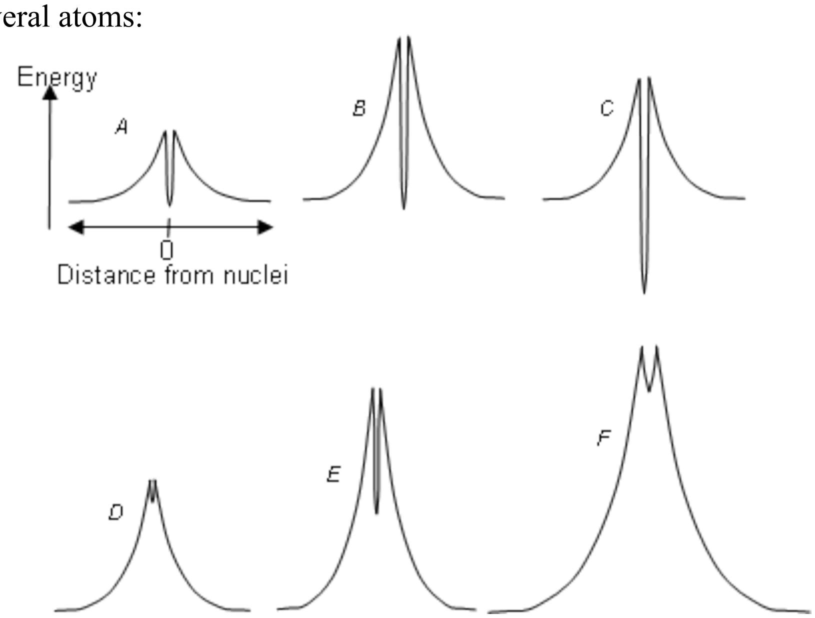
28.) Explain this in terms of Bernoulli's equation.

29.) In the fusion of a deuterium nucleus (one proton, one neutron) with a tritium nucleus (one proton, two neutrons), the deuterium nucleus must have enough initial kinetic energy to overcome the repulsion force due to the electrostatic interaction as the two nuclei get close together.

As the deuterium nucleus approaches the tritium nucleus, but before it collides with it, the energy of the deuterium atom is converted from one form to another. What happens?

a) electromagnetic energy is converted to electrostatic potential energy
b) electrostatic potential energy is converted to kinetic energy
c) kinetic energy is converted to electrostatic potential energy
d) gravitational potential energy is converted to electrostatic potential energy
e) kinetic energy is converted to thermal energy
f) electrostatic potential energy is converted to nuclear energy

Questions 30-37: As we have discussed in class, potential energy curves are a useful tool for making sense of nuclear processes such as alpha-decay, fission, and fusion. The potential energy curve for each different type of nucleus is different and depends on the number of protons and neutrons. Below are plots of the potential energy as a function of the distance from the center of the nuclei for several atoms:



30.) Describe why the potential energy curve for a nucleus has this type of shape. If you'd like you can discuss this in the context of the energy of a proton that starts out traveling towards the nucleus at a fast clip, and thinking about what forces the proton is feeling as it approaches, and how this is affecting its speed and its potential energy. Remember the graph is representing the potential energy only.

Questions 31-37: Examine the curves above and decide on the following:

31.) Which of these nuclei has the largest number of protons?
A B C D E F

32.) Which of these nuclei has the smallest number of protons?
A B C D E F

33.) For which of these nuclei does it take the most energy to add another proton?
A B C D E F

34.) Which nucleus would release the most amount of energy if fissioned?
A B C D E F

35.) Which nucleus would likely undergo alpha-decay the soonest?
A B C D E F

36.) Which of these nuclei is the most stable?
A B C D E F

37.) Which atom would release the most energy if undergoing fusion with a deuterium atom?
A B C D E F

38.) Which of the following are types of electromagnetic radiation? **(Check ALL that apply)**

a) Sound
b) Radio waves
c) Gamma rays
d) Infrared
e) X-Rays
f) Visible light
g) Pressure waves

39.) The color of a light wave is determined by

a) The speed of the light wave
b) The density of air that it is traveling through
c) Its wavelength and frequency
d) The size of the source
e) The intensity of the light beam

40.) What is the wavelength at which the most power is emitted for a lightbulb operating at 2500 °C? (Use the simulation, and be careful which temperature units you use!)

a) 1150nm
b) 1050nm
c) 950nm
d) 850nm
e) 750nm

You would like to make an incandescent light bulb that is more efficient, so a greater percentage of the electrical power going in gets turned into visible light. Consider the effect of the following changes in Questions 41-45:

41.) You increase the temperature of the filament. This will reduce the amount of (unwanted) radiation at 1100nm (T/F)

42.) Increasing the temperature will increase the efficiency of the bulb (T/F)

43.) You could improve the efficiency by increasing the surface area of the filament but keeping the temperature constant (T/F)

44.) If you increase the temperature of the bulb, the light will look… (select ALL that apply!)

a) Redder
b) Whiter
c) Dimmer
d) Brighter

45.) If you increase the temperature of the bulb, the lifetime of the bulb will be:

a) Shorter
b) Longer
c) Unchanged

46.) You have two initially uncharged dust particles. Each dust particle has a mass of 2.0 x10^{-12} kg. They are each 1.0 x 10^{-4} m in diameter and are 0.001 m apart. You take 10 electrons off of one and put them onto the other. The two dust particles are now

a. Attracted to each other
b. Repelled by each other
c. Neither attracted to nor repelled by each other.

47.) If the dust particles now exert a force on each other, how big is the force that one particle exerts on the other particle?

a. 0.015 N
b. 2.0 x 10^{-23} N
c. 1.0 x 10^{-17} N
d. 2.3 x 10^{-20} N
e. No force is acting.

48.) If you take another 10 electrons off the same particle and put them on the other, by what factor does the force between the 2 particles change?

a. 0.5
b. 1
c. 2
d. 4
e. 10

49.) If you now double the distance between the dust particles to 0.002m, by what factor does the force between them change?

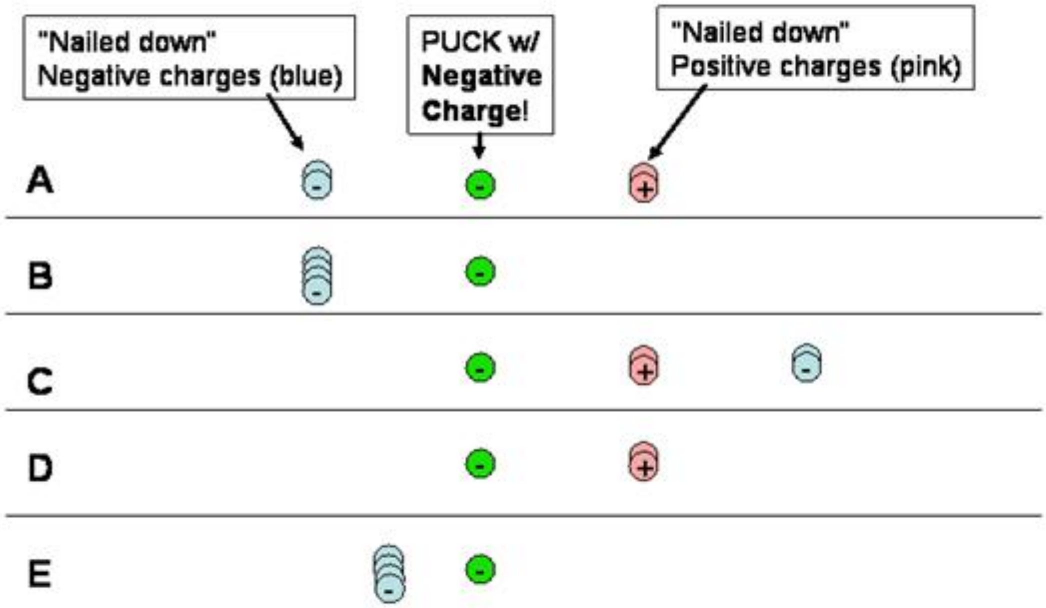
a. 0.25
b. 0.5
c. 1
d. 2
e. 4

Over the past decade there has been a revolution in the cleaning products line with the introduction of new dusting cloths (Swiffer, Grab-it, and other electrostatic dry cloths). These cloths use electrostatic forces to attract dust, dirt, and hair. The cloths are made of polyester and polypropylene, and like to grab electrons from any material (e.g. Dust, dirt, hair) that they come in contact with.

50.) Select which type(s) of dirt, dust, and hair will be effectively picked up by the duster. (Select **all** that apply.)

a) dirt, dust, and hair with an initial excess positive charge
b) dirt, dust, and hair with an initial neutral charge
c) dirt, dust, and hair with an initial excess negative charge

Questions 51-54: Consider the following 5 arrangements of charges. It may help to use the Electric Field Hockey Simulation (http://phet.colorado.edu/en/simulation/electric-hockey) to consider these arrangements, **but notice that here the puck has a negative charge (!) You can CHANGE the charge on the puck in the simulation by checking the box at the bottom**. When thinking about these arrangements, you should be sure you understand how Coulomb's Law works to tell you how the force the puck feels under each of the circumstances will differ.



Consider the following statements about these configurations.

51.) True/False: All of the pucks feel a force to the right.

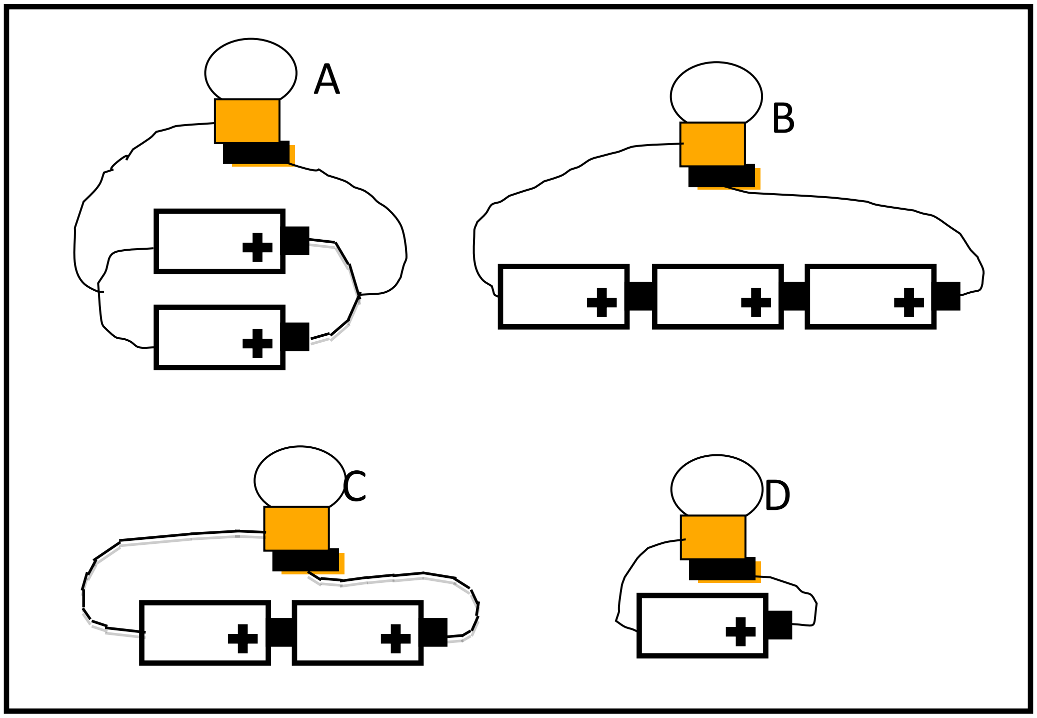
52.) True/False: The puck in C feels a greater force to the right than the puck in D.

53.) True/False: The puck in E feels a force to the right that is four times greater than that felt by the puck in B.

54.) True/False: The net force on the puck in A is zero.

Questions 55-64 refer to the figure below.

You are looking to purchase a new bike light and are considering the various models available. You are concerned about properties such as brightness and how long the rechargeable batteries will last. Below are some configurations for different lights. All the batteries are 6V batteries and all the bulbs are identical (have the same resistance). You can assume that the resistance of the connecting wires is zero.



55.) The light bulb will turn on in which of the cases – select **ALL** that apply:
A B C D

56.) Which circuit(s) produces the brightest bulb(s) – select **ALL** that apply:
A B C D

57.) In which circuit will the bulb stay at a constant brightness for longest – select **ALL** that apply:
A B C D

58.) Which bulbs are the same brightness – select **ALL** that apply:
A B C D

The voltage difference across the light bulb is an important factor in determining the brightness of the bulb. In case D, the voltage difference is 6 V since the light bulb is simply connected across one battery. (Again, ignore resistance of the wires.)

What is the voltage difference across the light bulb in the other cases?

59.) Case C?
a) 0V
b) 6V
c) 12V
d) 18V
e) Can't be determined from information given

60.) Case B?

a) 0V
b) 6V
c) 12V
d) 18V
e) Can't be determined from information given

61.) Case A?

a) 0V
b) 6V
c) 12V
d) 18V
e) Can't be determined from information given

62.) Consider circuit C. If the bulb has a resistance of 15 Ohms, what is the current flowing in the circuit?

a) 0.5 A
b) 0 A
c) 0.8 A
d) 15 A
e) 1.25 A

63.) How much electrical power is being used in the bulb in circuit C?

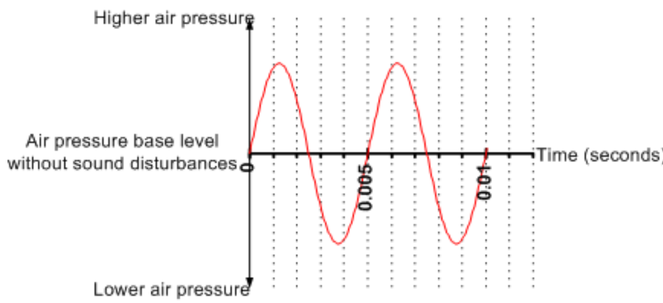
a) 9.6 W
b) 0.8 W
c) 180 W
d) 0 W
e) 12 W

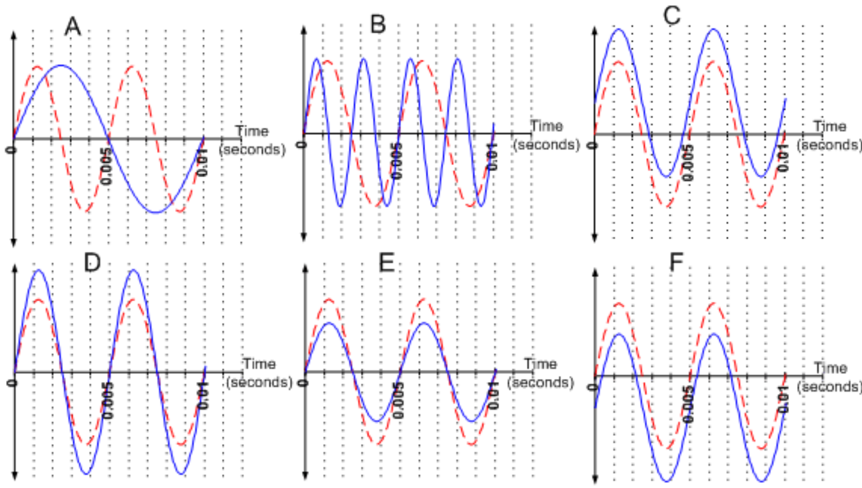
64.) How much electrical power is being produced by the batteries in circuit C? (The power produced by both batteries total, not the power produced by each individually.)

a) 12 W
b) 0W
c) 0.8 W
d) 180 W
e) 9.6 W

The following graphs relate to Questions 65-69.

In the top graph we have plotted the pressure measured at the listener's ear as a function of time for a 200 Hz tone generated by the speaker. In the lower graphs of pressure versus time, the dashed red line indicates the original 200 Hz tone. Select the solid blue curve(s) that represents the variation in the pressure at the eardrum versus time in the following situations (you might need to select more than one graph):





65.) The speaker is producing a 100Hz tone.

66.) The speaker is producing the original 200Hz tone at the original volume and the listener is at the same distance from the speaker.

67.) The listener has walked closer to the speaker.

68.) The speaker volume is turned down.

69.) The speaker produces a tone of a higher pitch.

70.) You hear a Concert A tone from the speaker. Describe the motion of the speaker and how this motion leads to our ears detecting Concert A tone. (include the chain of cause-and-effect logic that results in your hearing Concert A tone from the speaker)

BONUS QUESTION: (up to 2 points!!) What would be a good question for the final exam? List the problem, the solution, and WHY it would be a good problem.