Science One Term 2 Physics Exam

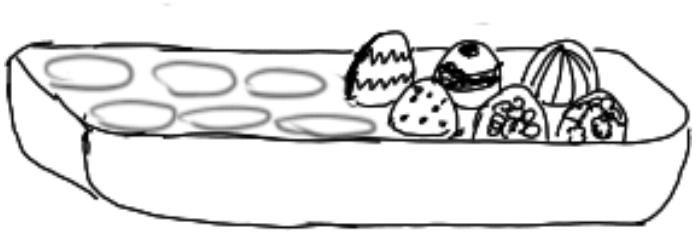
April 24, 2014

Name:
Student Number:
Bamfield Number:

Questions 1-27: Multiple Choice: 1 points each
Problems 1-5: Long answer: 28 points total

Multiple choice answers:

Formula sheet at the back (you can remove it…carefully!)

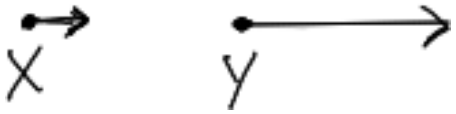


Question 1

Six eggs are placed at random into a carton that holds 12 eggs. We would say that having all the eggs on one side of the carton has a lower entropy than having three on each side because (*choose the best answer*):

A) Any specific configuration with three eggs on each side is more likely to occur than having all the eggs on one side.
B) Having three on each side is more random than having all the eggs on one side.
C) There are less distinct configurations with all 6 eggs on one side than configurations with three eggs on one side and three on the other.
D) None of the above: the entropy is the same in this case, because the number of eggs is half the number of holes.

Question 2

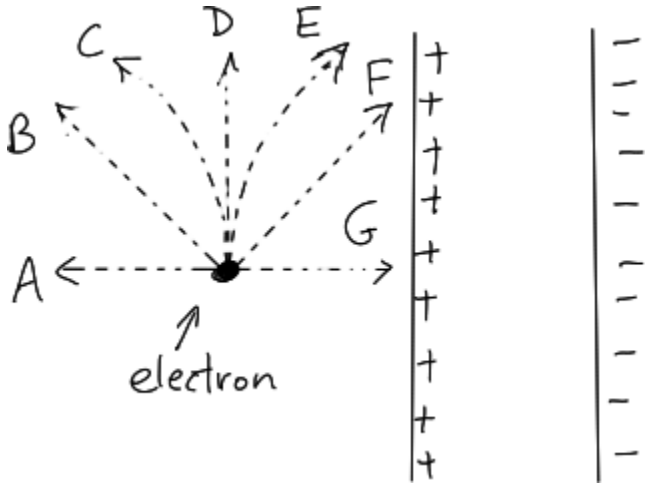


The electric field at two points X and Y is shown. We can say that

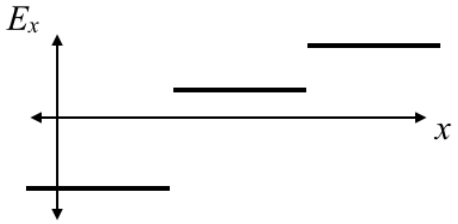
A) This field cannot be caused by a point charge
B) This field could be caused by a positive point charge to the left of A
C) This field could be caused by a negative point charge to the left of A
D) This field could be caused by a positive point charge to the right of B
E) This field could be caused by a negative point charge to the right of B

Question 3

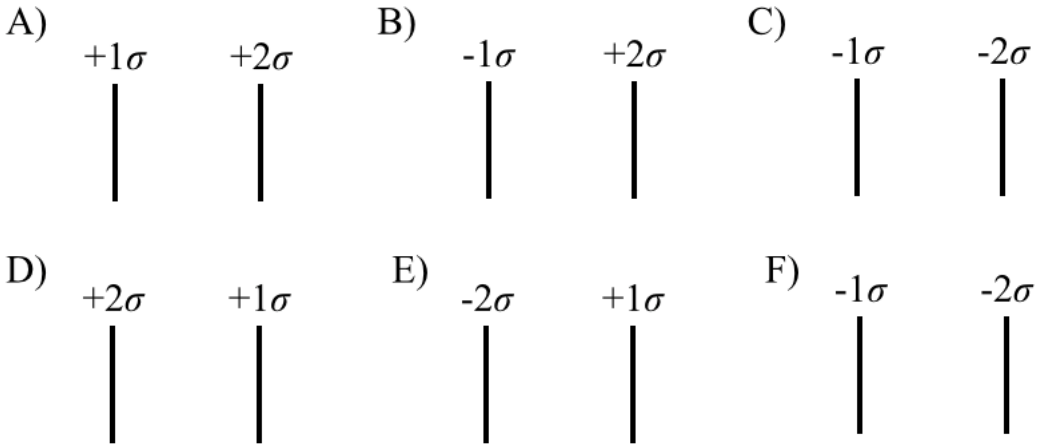
An electron is traveling upwards near an infinite line of positive charge and an infinite line of negative charge. Which of the choices below best represents the electron's subsequent trajectory?



Question 4

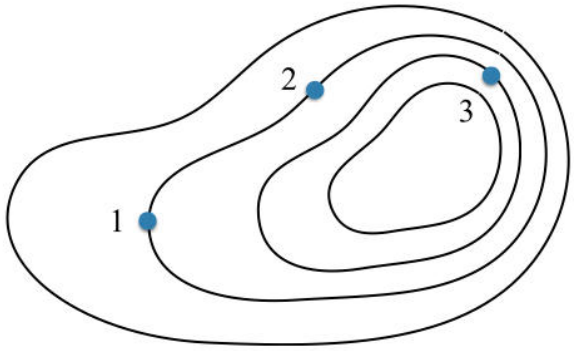


The graph to the right shows the electric field pointing in the x-direction as a function of x. Which of the following configurations of infinite planes could produce this electric field?



Question 5

Three electrons sit in an electric potential defined by the equipotentials drawn. Which electron experiences the greatest force? Choose the best ranking.



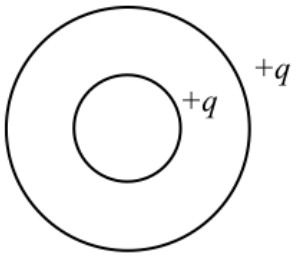
A) 1 = 2 > 3
B) 1 = 2 < 3
C) 1 > 2 > 3
D) 1 < 2 < 3
E) 1 = 2 = 3

Question 6

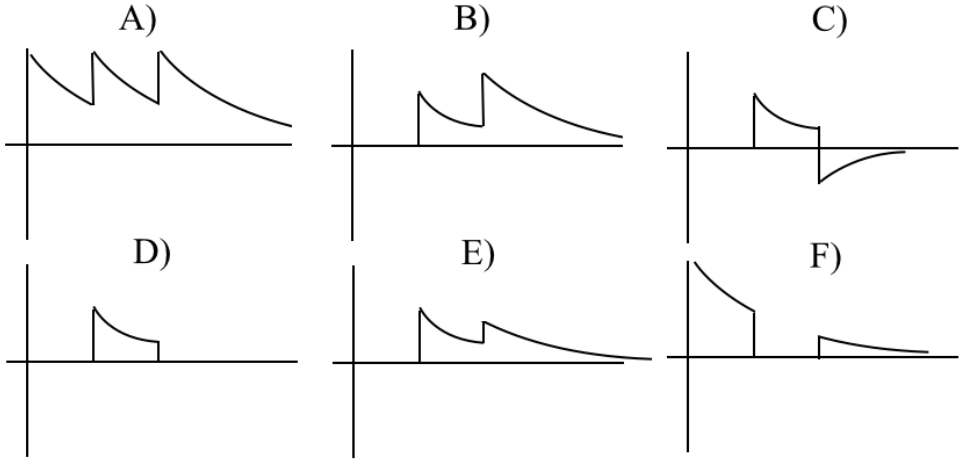
An copper ball carries a positive net charge. If the size of the ball grows (e.g. due to thermal expansion), we can say that the electric potential inside the ball

A) Increases
B) Decreases
C) Stays the same
D) Not enough information to answer.

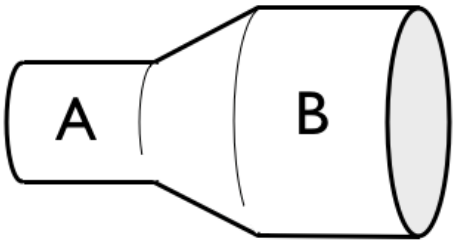
Question 7



The diagram to the right shows two concentric shells both with charge +*q*. Which of the pictures below best represents the strength of the electric field pointing away from the center?



Question 8



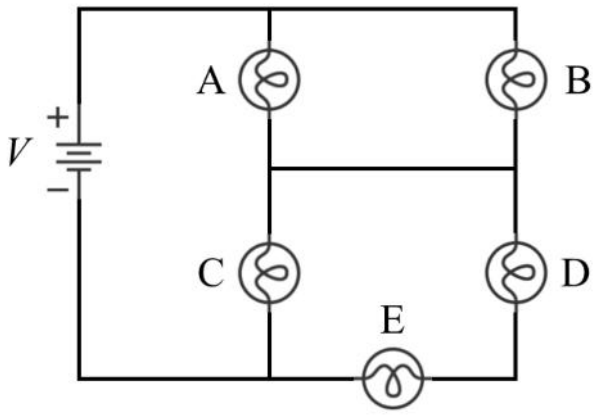
Consider the solid conductor shown to the right. Section A is half the radius of section B. A current is travelling from left to right. If the magnitude of the electric field in Section A is *E*, then the electric field in section B is:

A) E/4 B) E/2 C) E D) 2E E) 4E

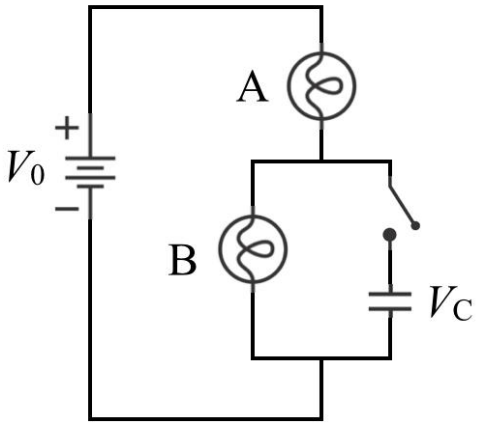
Question 9

You use a battery to fully charge a parallel plate capacitor. You then, *without disconnecting* the capacitor from the battery, double the distance between the plates. What happens to the electric field between the plates and the capacitance?

A) The electric field doubles and the capacitance halves.
B) The electric field doubles and the capacitance doubles.
C) The electric field stays the same and the capacitance halves.
D) The electric field stays the same and the capacitance doubles.
E) The electric field halves and the capacitance halves.
F) The electric field halves and the capacitance doubles.



Question 10: If all the lightbulbs in the circuit above have equal resistance, which is brightest?

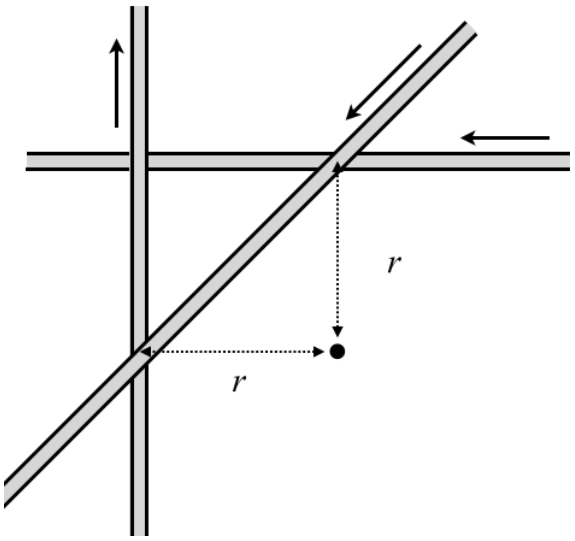


Question 11: The switch in the circuit above is closed for a long time. When the switch is opened, what best describes what happens in the circuit above?

A) Light bulbs A and B both suddenly go dim. They then return to their previous brightness.
B) Light bulbs A and B both suddenly go dim. They slowly return to different brightness than when the switch was closed.
C) Light bulb B goes out and A suddenly gets brighter. They then slowly return to their previous brightness.
D) Light bulb B goes out and A suddenly gets brighter. They slowly return to different brightness than when the switch was closed.
E) Light bulbs A and B both suddenly go brighter. They then return to their previous brightness.
F) Light bulbs A and B both suddenly go brighter. They slowly return to different brightness than when the switch was closed.
G) Nothing happens.

Question 12

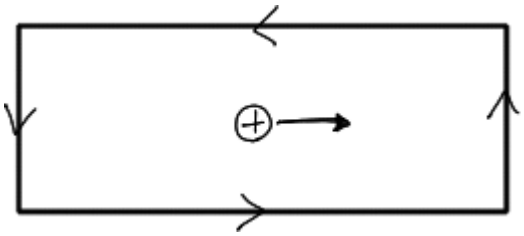
A current *I* runs in three wires as shown. At the black dot, what is the strength of the magnetic field out of the page?



A) $\frac{\mu I}{2\pi}\left(\frac{2}{r}-\frac{2}{\sqrt{2}r}\right)$
B) $\frac{\mu I}{2\pi}\left(\frac{2}{r}+\frac{2}{\sqrt{2}r}\right)$
C) $\frac{\mu I}{2\pi}\left(\frac{2}{\sqrt{2}r}\right)$
D) $\frac{\mu I}{2\pi}\left(-\frac{2}{\sqrt{2}r}\right)$
E) None of the above

Question 13:

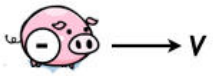
A positive charge is initially moving to the right inside a rectangular loop of current. The acceleration of this charge is:

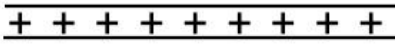


A) To the right
B) To the left
C) Upwards
D) Downwards
E) Into the page
F) Out of the page
G) Zero

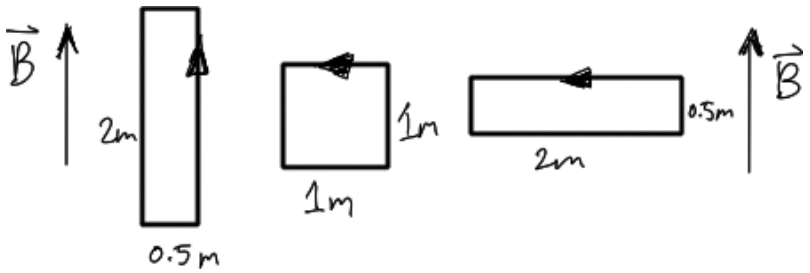
Question 14:

Ziggy the Piggy is about to enter a capacitor travelling a t a velocity *v*. In what direction must there be a magnetic field such that Ziggy continues to move in the same direction?





A) up
B) down
C) out of the page
D) in to the page
E) no magnetic field could do that



Question 15:

The three rectangular current loops shown have equal current and are in equal magnetic fields. Which experiences the greatest torque?

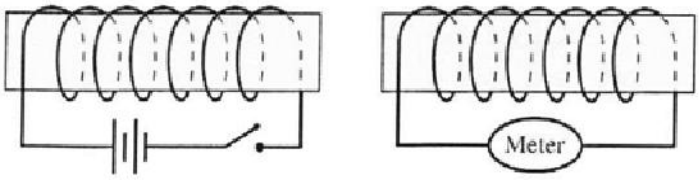
A) The first one
B) The second one
C) The third one
D) The first and third have the same torque, larger than the second
E) All the torques are equal

Question 16:

A ring-shaped UFO with a metal body takes off from the Arctic (it has been frozen there in the ice for 20,000 years). We can say that:

A) A clockwise current will be induced in the UFO body (looking down from the top)
B) A counterclockwise current will be induced induced in the UFO body (looking down from the top)
C) No current will be induced

Question 17:

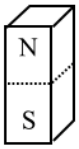


The switch has been closed for a long time, and then is opened. As the current in the left loop drops to zero, the meter on the right coil shows

A) a current flowing from right to left.
B) a current flowing from left to right.
C) no current flowing.

Question 18:

Read the following 4 statements regarding the magnet and the wire loop to the right. (The loop sort of looks like a donut, but I assure you that it's made of metal. You might even call it a metal donut rather than a loop).



1) Moving the magnet up causes the loop move up
2) Moving the magnet up causes the loop move down
3) Moving the magnet down causes the loop move up
4) Moving the magnet down causes the loop move down

Which of the statements are true?

a) 1 and 3
b) 1 and 4
c) 2 and 3
d) 2 and 4
e) none of the above choices are right.

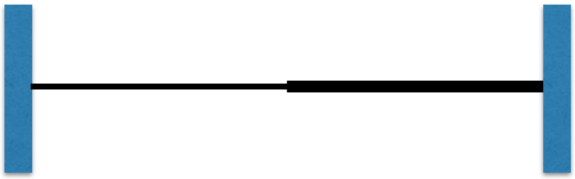
Question 19:

Light from the sun hits your window. When the light the sun passes from the air to the glass (*choose the most complete answer*):

a) the frequency stays the same.
b) the wavelength stays the same.
c) the wave velocity stays the same.
d) a and b.
e) a and c.
f) c and d.
g) a, b, and c.

Question 20:

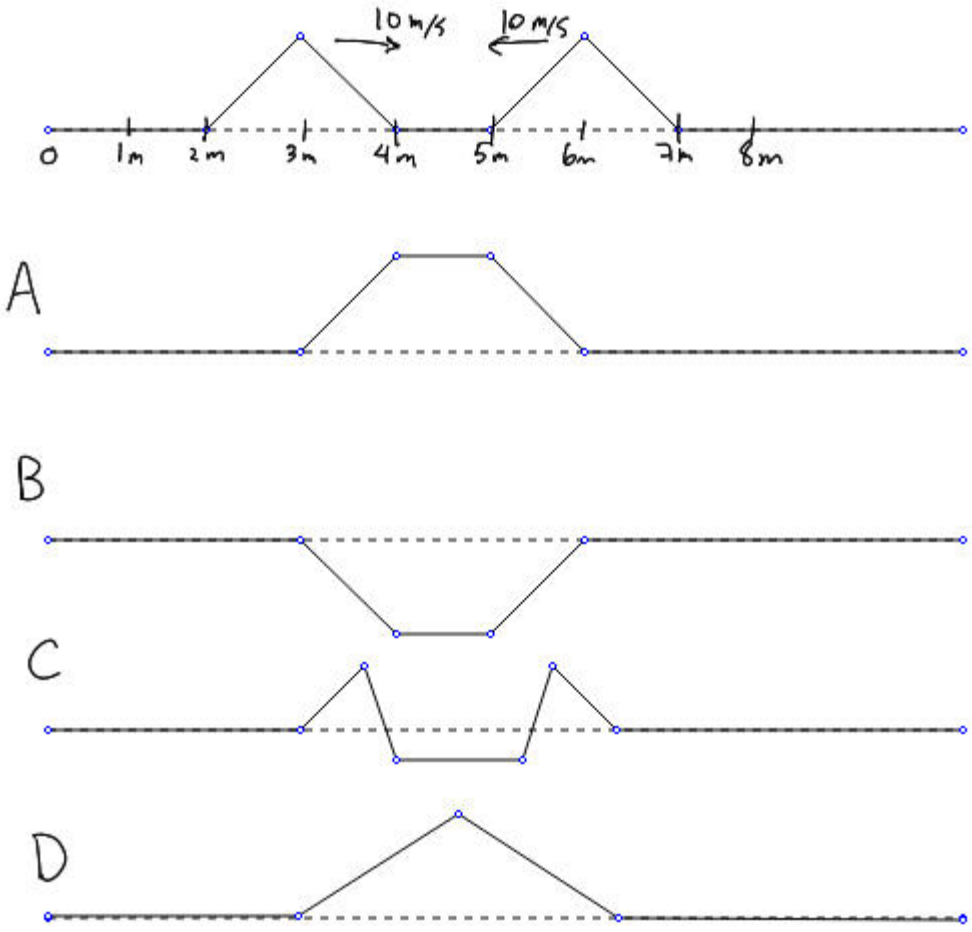
Two strings of equal length but different linear densities are tied together and attached to a wall on either side, as shown. If a pulse is generated at each wall, the two pulses will meet



a) in the middle.
b) in the heavier string.
c) in the lighter string.
d) the pulses won't meet.

Question 21:

The first picture below represents two small-amplitude pulses moving towards each other at some time on a stretched string. Which of the other pictures below represents the shape of the string 0.1s later?



Question 22:

If a double slit experiment is performed with one single photon and a screen sensitive enough to detect individual photons, what we would observe on the screen would be

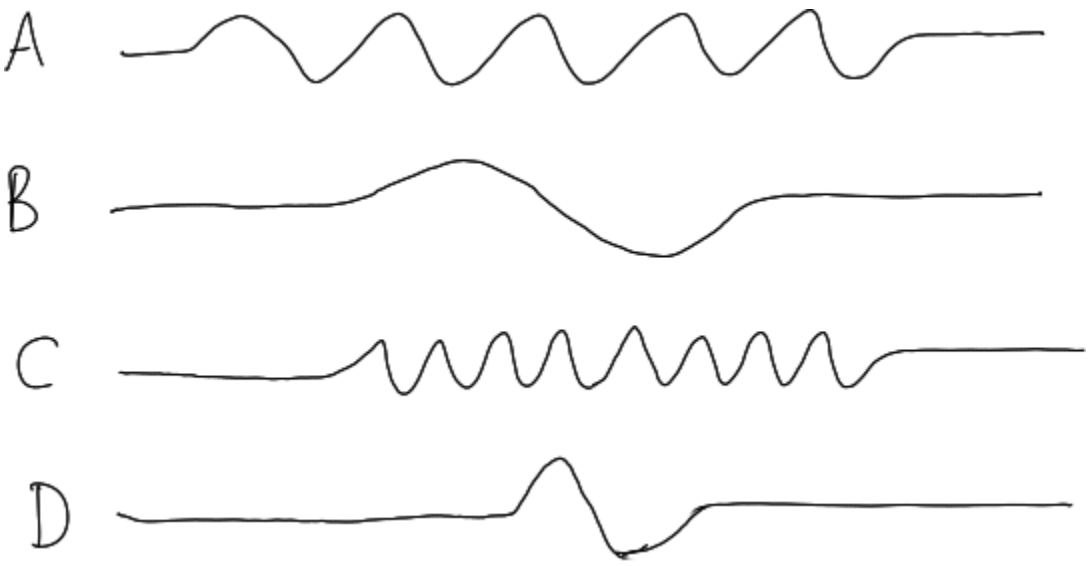
a) The image of a single particle behind one of the slits.
b) The same interference pattern as before, since the photon interferes with itself.
c) The image of a single photon at some location in one of the bright regions of the old interference pattern.
d) A new pattern that matches the square of the photon's wavefunction.

Question 23:

The figure above represents the photons in some beam of light with a particular wavelength and power/intensity. If size represents photon energy in the picture, which of the pictures below best represents a beam with double the wavelength but half the power/intensity ?

Question 24:

The wavefunction for a traveling electron is shown in the picture above. Which of the pictures below could represent the wavefunction for an electron travelling with half the velocity?



Question 25:

Of the answers to the previous question, for which wavefunction would we be able to predict with most certainty the result of a measurement of the electron's momentum?

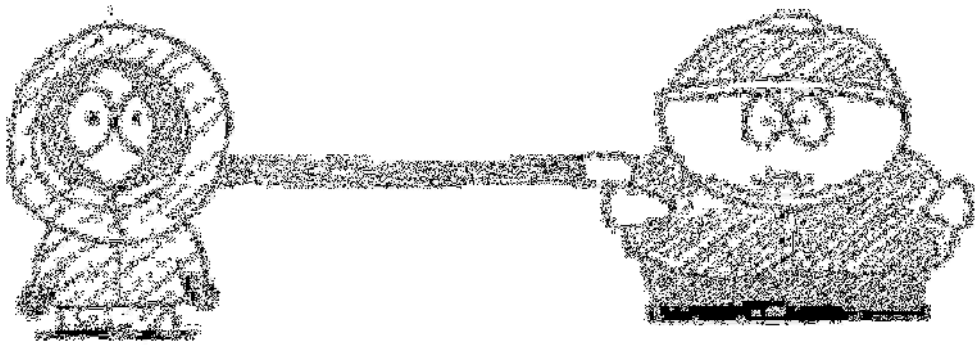
Question 26:

Consider the two electron states, both quantum superpositions of position eigenstates:

I) $\sqrt{\frac{1}{2}}|x=0\rangle + \sqrt{\frac{1}{2}}|x=1\rangle$ II) $\sqrt{\frac{1}{4}}|x=0\rangle + \sqrt{\frac{3}{4}}|x=1\rangle$

If we make a measurement of the electron's position in each case, we can say that

A) For both states, the electron will be found either at x=0 or x=1, with equal probability
B) For both states, the electron will be found between x=0 and x=1, but it will likely be closer to x=1 in state II)
C) For both states, the electron will be found either at x=0 or x=1, but with higher probability to be at x=1 for state II)
D) The electron will definitely be found at x=$\sqrt{\frac{1}{2}}$ for state I) and x = $\sqrt{\frac{3}{4}}$ for state II)



Question 27:

If Cartman (right) adjusts his flashlight from yellow light to short-wavelength gamma rays, it will most likely be more harmful to Kenny (left) because

A) A gamma ray beam has a higher intensity
B) Gamma rays are absorbed more easily by living cells
C) Gamma ray photons have more energy
D) The higher frequency of gamma rays causes Kenny's electrons to jiggle faster

Problem 1

Explain why heat is always observed to flow from hotter objects to colder objects and not the other way around. (**4 points)**

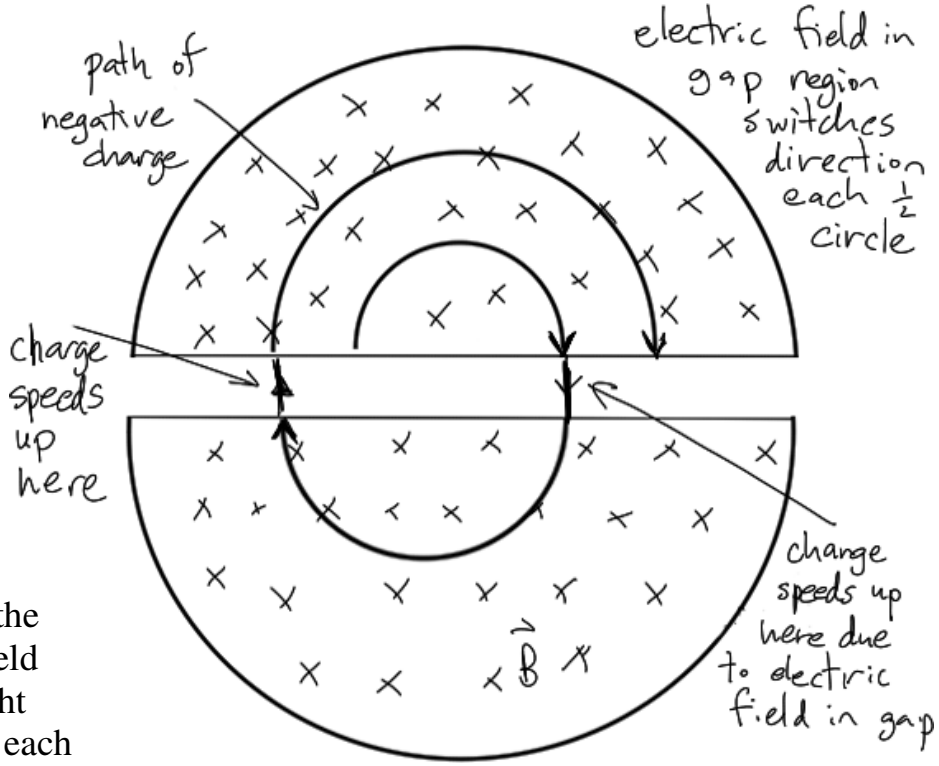
Problem 2

To protect himself from Space Crocodiles, Ziggy the Piggy decides to clone himself. Unfortunately, he only manages to make one negatively charged good clone. The other two are positively charged evil clones. They're currently held in the following position.

a) Sketch and label equipotential lines on the charge configuration above. Plot the 0 V equipotential as well as at least two equipotentials both above and below 0 V. **(3 points)**

b) If the positive charges are +2 nC and the negative charges are -2 nC and they form a square with sides 2 m, what is the potential energy of the configuration? (**2 points)**
(*Assume that potential energy zero corresponds to having all the charges far apart*)

Problem 3



UBC houses TRIUMF, the world's largest cyclotron. A cyclotron consists of two large D-shaped regions with magnetic fields. These D-shaped regions (known as "dees") are responsible for bending a charged particle in a circle while it's being accelerated.

The particle is accelerated by an electric field in the gap between the two dees. The direction of this field oscillates such that it is in the right direction to speed up the particle each time it crosses the gap.
It takes the particle 2.0×10^{-6} s to do a full circle, so the oscillation frequency of the electric field is 500 kHz.

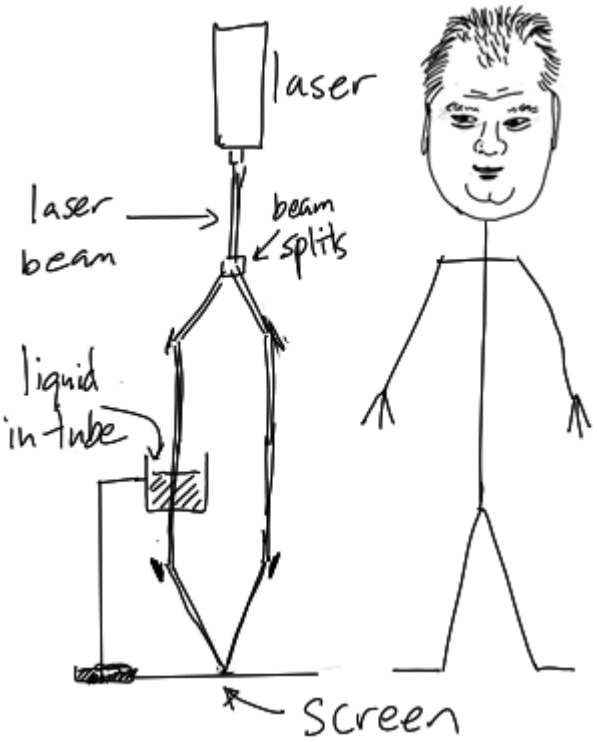
a) Show that the time taken for a particle to enter one side of the dee and complete half the circle does not change as it gets faster. **(3 points**)

b) Given the cyclotron frequency of 500Hz, calculate the strength of the magnetic field at TRIUMF. **(3 points**)

c) Between each dee, H^- atoms are accelerated by a 50 kV potential (which is responsible for the electric field). How many individual accelerations are required to get the H^- ions to 500 MeV, enough energy to travel at 0.75 the speed of light? (**1 point**)

Problem 4

As part of his re-election efforts, mayor-scientist Rob Ford decides to monitor his alcohol consumption more closely. Rather than relying on his own recollections, he designs an apparatus to determine his recent consumption levels indirectly by measuring the index of refraction of his urine.

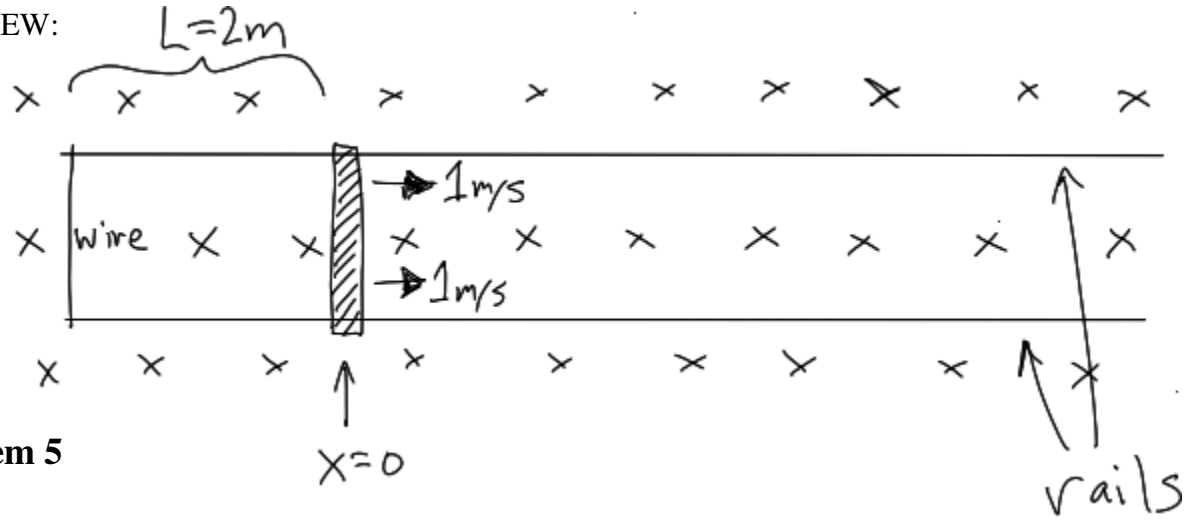


Mr. Ford's apparatus is shown in the diagram. Light from a laser is split into two beams, and recombined. The paths of the two beams are symmetrical, but one of the beams is passed through a tube of the liquid as shown. As liquid is added to the tube, it is found that the image on the screen becomes darker and brighter repeatedly.

a) Explain why this happens. (**3 points**)

b) On a particular day, Mr. Ford determines using a tube with diameter 2cm and light with wavelength 500nm that the image goes from bright to dark to bright again every time 0.5 microliters of liquid is added. What is the index of refraction of Rob Ford's urine on that day? (**3 points**)

TOP VIEW:



Problem 5

Two perfectly conducting rails separated by 1m sit in a uniform downward magnetic field of 1T. The rails are connected at one end by a fixed perfectly conducting wire, and a freely movable bar with mass 1kg and resistance 1 Ohm is placed across the rail with an initial velocity of 1m/s away from the end.

a) Even though there is no friction, the bar is observed to slow down and ultimately come to rest (as $t \rightarrow \infty$). Explain why. **(3 points)**

b) If the initial location of the bar is x=0, determine the final location of the bar. (**3 points**)

FORMULA SHEET

$\mathbf{F} = m\mathbf{a}$
$F_r = -dU/dr$ $W = -\Delta U = -\int \mathbf{F}\cdot\mathbf{dr}$

$\mathbf{F} = q\mathbf{E}$ $U = q\ V$
$E_r = -dV/dr$ $\Delta V = -\int \mathbf{E}\cdot\mathbf{dr}$

$E = kq/r^2$ $E = \eta/(2\varepsilon_0)$ $E = 2kp/r^3$ $p = qs$ $\text{Flux} = Q_{enc}/\varepsilon_0$

$k = 9 \times 10^9\ N\ m^2/C^2$ $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/(N\ m^2)$ $e = 1.6\times10^{-19}\ C$ $\mu_0 = 4\pi\times10^{-7}\ N/A^2$

$\mathbf{F} = q\mathbf{E} + q\ \mathbf{v} \times \mathbf{B}$ $\mathbf{F} = I\ \mathbf{l} \times \mathbf{B}$ $\boldsymbol{\tau} = \boldsymbol{\mu} \times \mathbf{B}$ $\mu = I\ A$

$\mathbf{B} = \mu_0/(4\pi)q\ \mathbf{v} \times \mathbf{r} / r^3$ $\mathbf{B} = \mu_0/(4\pi)I\ \mathbf{ds} \times \mathbf{r} / r^3$ $B = (\mu_0 / 2\ \pi)\ I/d$ $B = \mu_0\ (N/L)\ I$

$V = IR$ $C = Q/V$ $P = IV$

$R = \rho LA$ $\sigma = n_e e^2\tau/m = 1/\rho$ $v_d = e\ \tau\ E/m$ $I = e\ n_e\ A v_d$

$Q(t) = Q_0 \exp(-t/RC)$

$\varepsilon = |d\Phi_m/dt|$ $\Phi = \mathbf{B}\cdot\mathbf{A} = BA\cos(\theta)$ $\oint \vec{E} \cdot d\vec{s} = -d\Phi_m/dt$

$\lambda\ f = v$

$E = hf$ $p = h/\lambda$ $\Delta x\ \Delta p = h/(4\ \pi)$ $h = 6.6 \times 10^{-34}\ Js$