Name ________________

Physics 104 - Exam 2

April 13, 1999

Instructions

- *Put your name on every page first! (5 points will be deducted if your name is not on every page).*
- *Please answer all questions in the space provided on these pages. (If you need more room use the back of the page and say (OVER)).*
- *Read all the questions first. Then start on the ones you find easiest..*
- *If you don't understand what a question is asking raise your hand and ask.*
- *Write clearly and make drawings whenever it will help explain what you mean. Partial credit will be given only if we can figure out what you are trying to do or say.*

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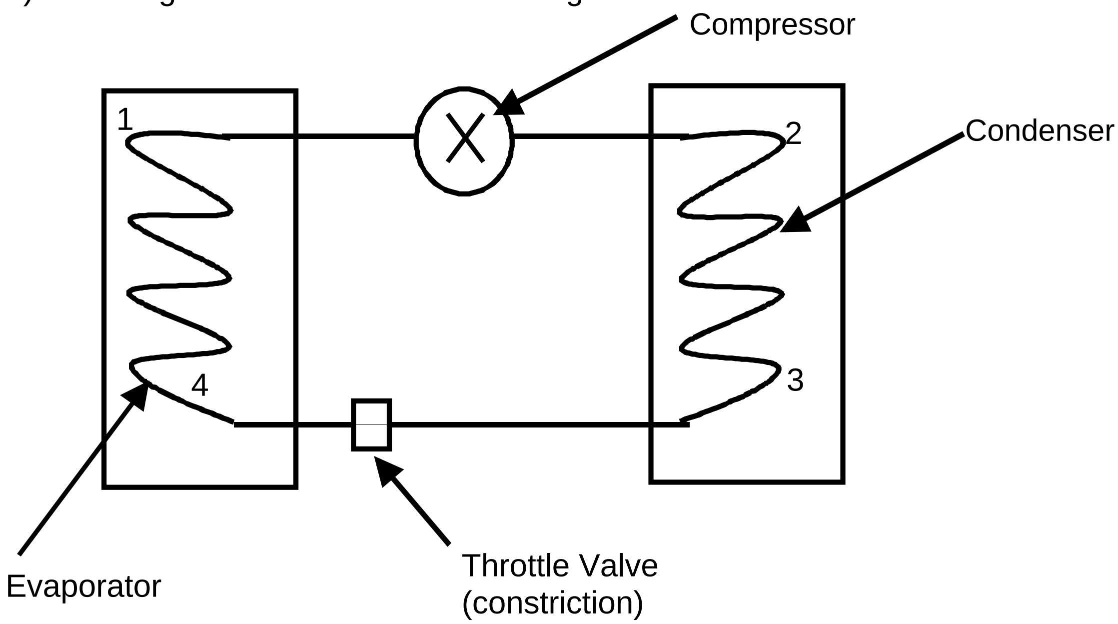
1) In the figure below an air conditioning unit is shown:



For each of the four marked locations (1-4) answer in the chart below whether: the fluid is a liquid or gas; the fluid is hot, warm, cool or cold; heat is flowing into or out of the fluid; the fluid is at high or low pressure and finally is the location inside or outside the house. (Each answer is worth 1 point).

Location	State: Liquid or Gas	Temperature: Hot, Warm, Cool or Cold	Heat Flow: In, Out, None	Pressure: High or Low	Inside the house or Outside
1	Gas	Cool	In (or None)	Low	Inside
2	Gas	Hot	Out	High	Outside
3	Liquid	Warm	Out (or None)	High	Outside
4	Liquid	Cold	In	Low	Inside

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2) An ice cube is placed in a glass of warm water:

a) (2 points) As it melts what happens to the entropy of the ice cube?

It increases!

b) (2 points) How does the entropy of the warm water change as it cools?

It decreases.

c) (2 points) How does the entropy of the entire system change?

It increases!

d) (4 points) Does the **first** law of thermodynamics prohibit the ice cube from spontaneously getting colder and the water getting hotter? Explain.

The first law tells us that energy is conserved, but it doesn't say anything about the direction heat will flow. So it's OK with the first law if this happens.

e) (5 points) Explain why the situation described in part d) (above) doesn't happen.

The 2^{nd} law tells us that the entropy of an isolated system always increases. In this case the entropy of the ice would decrease more than the warm water would increase. Thus the 2^{nd} law says it can't happen!

3) Explain what happens during each of the four strokes of the internal combustion engine. Make sure to mention whether the piston is moving down or up during each stroke. (5 points each)

a) Induction (Intake):

The piston moves down creating a vacuum that sucks air and fuel into the cylinder. The intake valve is open.

b) Compression:

The piston moves up compressing the fuel air mixture. (Valves are closed).

c) Power:

The piston moves down as the spark plug ignites the mixture and it explodes. This creates very high pressure and pushes the piston down very hard. (Valves are closed).

d) Exhaust:

The piston pushes the burnt fuel out the exhaust. (The exhaust valve is open).

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4) Two charged spheres are separated by a distance of 2cm. The charge on each is $+2 \times 10^{-6}$ C. (Hint: $K=9 \times 10^{9}\ N\ m^2 /C^2$)

a) (5 points) Find the force pushing the spheres apart.

$F = K q_1 q_2 / r^2 = 9 \times 10^9\ N\ m^2 /C^2 \times (2 \times 10^{-6}\ C)^2 / (0.02m)^2 = 90N$

b) (5 points) If you double the charge on one of the spheres. How far away would you have to position it so that the force on it remains the same?

If you double the charge on one sphere the force goes up by a factor of two so to compensate you must r^2 bigger by a factor of two so r goes up by the square root of 2 (1.4). So the new r is 1.4 * 2cm = 2.8cm

c) (5 points) Explain why charge moves to the outside of a metal object.
Like charges repel each other. On a conductor they are free to move so they move as far from each other as possible which puts them on the outside of the conductor. (Inside the conductor there can't be an electric field so the charges move to the outside to cancel the field).

5) In a photocopier a photoconductor is initially negatively charged by a corona wire.

a) (5 points) What happens to the charge on the area of the photoconductor which is hit by light?
The photoconductor starts to conduct so that the negative charges are free to move to the positive charges on the opposite side of the belt and cancel each other out. So the area hit by the light is neutralized.

b) (5 points) What charge must be applied to the toner so that it is picked up by the photoconductor? Explain.

The photoconductor starts out negative so the areas we want to pick up toner are negative (i.e. those areas not hit by light). So we charge the toner positive to be attracted to the belt.

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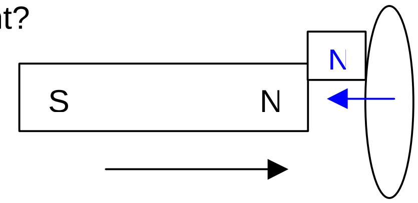
6) Answer only **four out of** the following **six** questions (5 points each):

a) If you push the north pole of a bar magnet toward the center of a loop of wire, what will happen in the wire and if a magnet field is created which way will it point?



Because of Lenz's law the conductor develops a current in a direction to oppose the change in magentic flux. So in this case the induced current produces a magnetic field opposite to the magnet (N pointing to the left). This causes the loop to be repelled by the magnet.

b) Why do high performance (high compression) engines need high octane fuel? When you compress gas it gets hot. High compression engines compress the misture above the ignition temperature of "regular" fuel. High octane fuel can withstand these higher temperature without igniting prematurely. Premature ignition casues "knocking" which loses power.

c) Why don't diesel engines need a spark plug? In a diesel engine, air is compressed to a very high pressure and temperature. Fuel is then injected which burns because of the high temperature gas.

d) Why can't you levitate a train using just permenant magnets?

With permenant magnets you can't attain a stable equilibrium. The magnets would repel but if the train moved off center it would keep going off...

e) How does the sharp point of a lightning rod work to prevent lightning from striking at all?

The high concentration of charge (and high electric field) near the point causes a corona discharge which discharges the cloud before it builds to a point of lightning.

f) Explain why a magnetic levitation only works at high speeds for a maglev train.

At high speeds the magnetic field of the superconductors induces a current in the levitation coils which doesn't have a chance to die out. Also moving the magnet quickly produces a bigger levitation current.