PHY 101 Practice Final

Review Sessions: Tuesday, Dec. 12, 11AM-12PM and 4-5PM in PB202

Please be sure to show your work where it is requested. If no work is shown where it is requested, you will not receive any points. Also, partial credit will be given where appropriate, so *show me your physics thoughts.*

Please answer the following multiple choice questions. Circle only one answer per question.

(1) Faraday's law of induction states that the voltage induced in a rectangular loop of wire is proportional to
A. the magnetic flux.
B. the time variation of the magnetic flux.
C. current divided by the time.
D. the magnetic flux density times the area of the loop.

(2) Doubling the diameter of a loop of wire produces what change of induced voltage in the presence of an external magnetic field?
A. The induced voltage is 4 times as much.
B. The induced emf is twice as much.
C. There is no change in the induced emf.
D. The induced emf is 6.28 times as much.

(3) If the average kinetic energy of a *constant* volume of ideal gas increases, what must be true?
A. the density decreases
B. the pressure increases while the temperature stays the same
C. the temperature increases while the pressure stays the same
D. both the pressure and temperature increase

(4) The south end of a bar magnet is pushed downward toward a wire loop in the plane of the paper. In which direction is the induced current, and which way is the induced magnetic field?
A. clockwise, out of the paper
B. clockwise, into the paper
C. counter-clockwise, out of the paper
D. counter-clockwise, into the paper

(5) When a person stands on a scale, which of the following is not a force exerted on the scale?
A. a contact force due to the floor
B. a contact force due to the person's feet
C. the weight of the person
D. the weight of the scale

(6) What is the unit of heat?
A. N
B. J
C. N/m^2
D. J/m^2

(7) To be dimensionally consistent, force, pressure, and length must be related as follows:
A. force = pressure^2 length^2

B. force = pressure^2 length
C. force = pressure length^2
D. force = pressure length

(8) What physical quantity is represented by the area under a curve on a P-V diagram where pressure is in Pa and V is in m^3
A. Area in meters^2
B. Work in Joules
C. Heat in Watts
D. Heat in Joules

(9) As a system undergoes a constant-volume process
A. the pressure does not change.
B. the internal energy does not change.
C. the work done on the system is zero.
D. the entropy stays the same.

(10) Which of these statements are implied by the second law of thermodynamics?
A. The entropy of an engine operating in a cycle never decreases.
B. The increase in internal energy of a system in any process is the sum of the heat absorbed plus work done on the system
C. A heat engine, operating in a cycle, that exhausts no heat to the low-temperature reservoir is impossible.
D. Both A and C.

(11) How does the resistance of a piece of conducting wire change if both its length and diameter are quadrupled?
$R = \rho \frac{L}{A}$
A. Remains the same
B. half as much
C. third as much
D. fourth as much

(12) A vertical spring system with a bob having mass m is set into motion with amplitude A. When the bob replaced by one having mass $4m$, the following can be concluded:
A. The period is 0.7 times as large as before
B. The period is unaffected.
C. The period is twice as large as before.
D. The period is half as large as before.

$T = 2\pi\sqrt{\frac{m}{k}}$

(13) The net force on a moving object suddenly becomes zero. The object then
A. stops abruptly.
B. stops during a short time interval.
C. changes direction.
D. continues at a constant velocity.

(14) A blue ball is dropped from the roof of a tall building simultaneously with the horizontal launch of a red ball. Which statement is true?
A. the red ball strikes the ground first with the higher speed
B. both balls hit the ground at the same time, but the red ball has the higher speed
C. the blue ball strikes the ground first, but with the lower speed
D. both balls hit the ground at the same time with the same speed

(15) Two balls are thrown from the roof of a building with the same initial speed. One is thrown

horizontally while the other is thrown at an angle of 30 degrees above the horizontal. Which hits the ground with the greatest speed?
A. The one thrown horizontally
B. The one thrown at 30 degrees
C. They hit the ground with the same speed.
D. The answer cannot be determine with the given information.

Kinetic energy

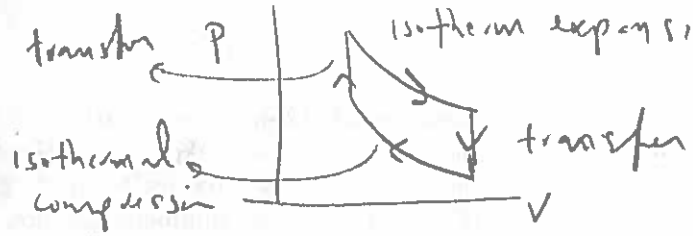
(16) The electric field of a point charge decreases with distance r from the point charge as
A. $1/r^2$
B. $1/r$
C. $1/r^{1/2}$
D. $1/r^3$

Now respond to the following short answer questions. Please answer TWO out of THREE for questions (17)-(19). CLEARLY indicate which ones you would like to be graded on the front sheet of the exam.

(17) Why do lakes and rivers freeze first at their surfaces?

H_2O is more dense at around 4°C than compared to at 0°C, i.e. ice is less dense than water.

(18) Describe how a heat engine works–it could be a Stirling engine or even a combustible engine. What does a heat engine do? Can even an ideal engine (with no friction between moving parts, etc.) be 100 percent efficient? Please answer each part of the question.



Heat engine takes heat and converts it to mechanical energy. An ideal engine cannot be 100%.

(19) A ping-pong ball that has been dented during hard play can often be restored by placing it in hot water. Explain *why* this works.

The pressure of the air inside the ping pong ball increases as the ball is heated up and so pushes out the dents.

Please answer TWO out of THREE for questions (20)-(22). CLEARLY indicate which ones you

would like to be graded on the front sheet of the exam.

(20) Describe how a direct current (DC) motor works. Be sure to list the parts and describe the function for each part. What does a DC motor do? Please answer each part of the question.

DC motor turns electrical energy into mechanical energy.

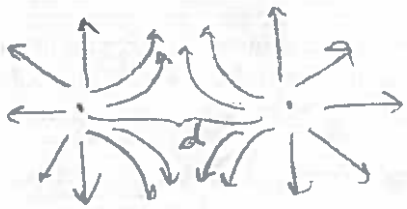
Parts: 2 permanent magnets
1 electromagnet -- magnet only when I running
1 split ring commutator - changes direct. of I
brushes; flywheel

changing I changes poles of magnets → like poles repel and unlike poles attract; changing I at the right time rotates the flywheel since

(21) An SUV collides with a Mini Cooper convertible. Is the force exerted on the Mini by the SUV greater than, equal to, or less than the force exerted on the SUV by the Mini? Explain what physics principle/law is at work here.

The force on the SUV by the Mini is equal and opposite to the force on the Mini by the SUV. This is Newton's 3rd Law.

(22) Draw the electric field lines for two protons at distance d apart from each other.



Now answer TWO of the following THREE quantitative questions (23)-(25). Please clearly indicate which ones you would like to be graded on the front sheet of the exam. You are welcome to approximate g as 10 m/s^2, ϵ_0 as 9×10^{-12} $C^2/(N\,m^2)$, the mass of the electron as 9×10^{-31} kg, the charge of the electron as -2×10^{-19} C, and $k_B = 1 \times 10^{-23} J/K$ to obtain numbers. See how close you come to reaching a number without the use of a calculator.

(23) An external magnetic field pointing along the central axis of a 50 turn coil of radius 3 cm increases from 0 to 2 T in 3 seconds.
(a) If the resistance of the coil is 3 Ohms, what is the magnitude of the induced current in the coil?

$$|\Delta V_{ind}| = \left|\frac{N\Delta\Phi_B}{\Delta t}\right| = \left|\frac{50\,(2\text{ T})\,\pi\,(3\times10^{-2}\text{ m})^2}{3\text{ s}}\right|$$

$$= (300\times\pi)\times10^{-4}\text{ Volts} = .09\text{ Volts}$$

Using $\Delta V = IR$ → $I_{ind} = \frac{.09\text{ Volts}}{3\,\Omega} = .03\text{ A}$

(b) What is the direction of the current if the external magnetic field points away from the viewer as the viewer looks down the central axis of the coil?

By Lenz's law, the induced field is toward the viewer and so the current must be CCW by the second RHR (the one for loops)

(24) The alveoli—tiny air sacs in the lungs— have an average radius of 0.1 mm and are approximately spherical. If the pressure in the sacs is 1×10^5 N/m^2), and the temperature is 310 K (average body temperature), how many air molecules are in an alveolus?

Use $PV = N k_B T$

$$\frac{PV}{k_B T} = N = \frac{\left(1\times10^5 \frac{N}{m^2}\right)\frac{4}{3}\pi\left(1\times10^{-4}\,m\right)^3}{\left(1\times10^{-23}\,J/K\right)(310\,K)} = \frac{4\times10^{-7}\,J}{310\times10^{-23}\,J}$$

$$= \frac{4}{310}\times10^{16}$$

(25) Calculate the maximum possible efficiency of a heat engine that uses surface lake water at 18 degrees Celsius as a source of heat and rejects waste heat to the water 0.1 km below the surface where the temperature is 4 degrees Celsius. (Hint: What units of temperature should you be using?)

Use $e = 1 - \frac{T_c}{T_H} = 1 - \frac{277.4\ \text{Kelvin}}{273+18\ \text{Kelvin}}$

$$= 1 - \frac{277}{291} \approx 1 - .95 = .05 \text{ or } 5 \text{ percent}$$

Please answer TWO of the next THREE questions (26)-(28).

(26) A spring gun with spring constant $k = 10$ N/m is used to shoot a 100 g ball horizontally. Initially the spring is compressed by 20 cm. The ball loses contact with the spring and leaves the gun when the spring is uncompressed. What is the speed of the ball when it hits the ground 1 m below the spring gun?

$m = 100$ g

$k = 10$ N/m

compress 20 cm

Use conservation of energy

≈ 5 m/s

$v_f = \sqrt{24\ m^2/s^2}$

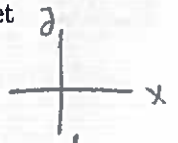
$K_i + U_{ei} + U_{gi} = K_f + U_{ef} + U_{gf}$

$K_i = 0$, $U_{ef} = 0$, $U_{gf} = 0$ (1 m is ground, spring relaxed)

$$\tfrac{1}{2}kx^2 + mgh = \tfrac{1}{2}mv_f^2$$

$$v_f = \sqrt{\frac{2\left(\frac{1}{2}kx^2 + mgh\right)}{m}} = \sqrt{\frac{kx^2}{m} + 2gh} = \sqrt{\frac{(10\ N/m)(.2m)^2}{.1\ kg} + 2\left(10\ m/s^2\right)(1\ m)}$$

(27) Isabella slides a paper plate with a slice of pizza across a horizontal table to her friend Petra. The coefficient of friction between the table and plate is 0.4. If the pizza must travel 50 cm to get from Isabella to Petra, what initial speed should Isabella give the plate of pizza so that it stops just when it gets to Petra?



what's the acceleration? $\uparrow N$ $\downarrow mg$ $\Sigma F_y = N - mg = 0 \rightarrow mg = N$

$\Sigma F_x = ma_x$

$-f_k = ma_x$

$-\mu_k N = ma_x$

$-\mu_k mg = ma_x$

$a_x = -\mu_k g$

Then use $v_f^2 = v_i^2 + 2a_x\Delta x$

with $v_f = 0$

$\Delta x = .5\,m$

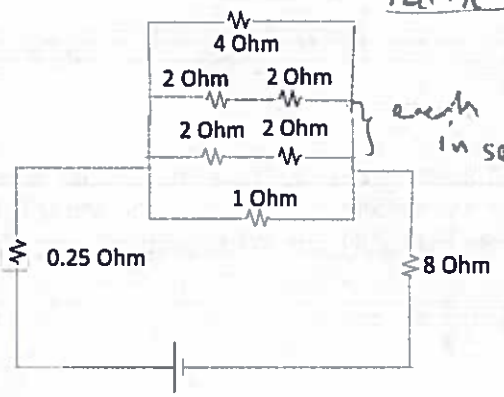
$v_i = ?$

$v_i = \sqrt{-2a_x\Delta x}$

$v_i = \sqrt{-2(-\mu_k g)\Delta x} = \sqrt{2\mu_k g\Delta x}$

$= \sqrt{2(.4)(10\,m/s^2)(.5m)} \rightarrow \sqrt{4\,m^2/s^2} = 2\,m/s$

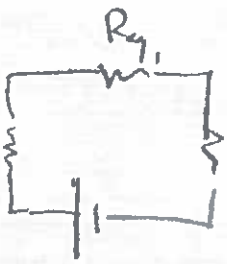
(28) Consider the circuit diagram below.



each 2 in series → 4Ω

in parallel

(a) Find the equivalent resistance for the circuit.



$\frac{1}{R_{eq_1}} = \frac{1}{1\Omega} + \frac{1}{4\Omega} + \frac{1}{4\Omega} + \frac{1}{4\Omega}$

$\frac{1}{R_{eq_1}} = \frac{1}{1\Omega} + \frac{3}{4\Omega}$

$R_{eq_1} = \frac{4}{7}\Omega \leftarrow \frac{1}{R_{eq_1}} = \frac{7}{4\Omega}$

$R_{eq} = \frac{1}{4}\Omega + \frac{4}{7}\Omega + 8\Omega$

$R_{eq} = \frac{7}{28}\Omega + \frac{16}{28}\Omega = \frac{224}{28}\Omega = \frac{247}{28}\Omega$

(b) If the battery is a 40 V battery, what is the current going through the 8 Ohm (Ω) resistor?

$\Delta V = IR_{eq} \rightarrow \frac{\Delta V}{R_{eq}} = I$ in circuit

$\frac{40V}{247}(28)\frac{1}{\Omega} = \frac{1120}{247}\,A$

same through 8Ω resistor