SAMPLE FINAL

Name:_____________________

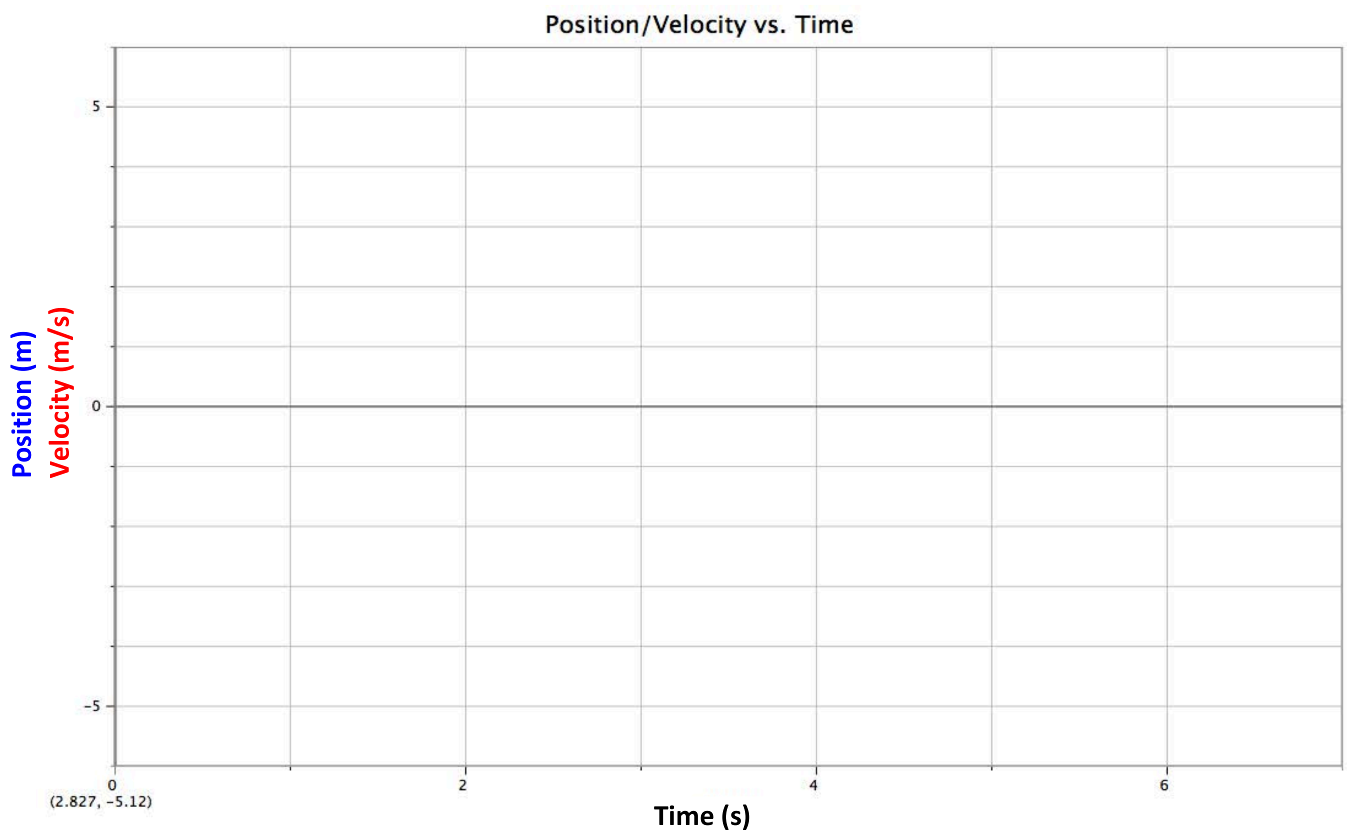
	SCORE
Part 1 (24 pts)	
Part 2 (80 pts)	
% OUT OF 100	

This sample final is indicative of the style of your final exam. Don't expect to see the same questions on your final. Notice that the topics that can be covered on this exam are limited. Don't expect to see the same topical coverage as this sample exam. You should be prepared to answer questions from any topic that was covered during the semester.

Part 1 Conceptual Questions (3 points each, unless noted)

Answer the first plus six of the remaining nine questions. You must clearly indicate the questions to be graded; otherwise the first seven completed problems will be graded.

1. **A 1.0kg object is attached to a spring on a horizontal surface. The spring constant is 4.0N/m. At t=0s, the object is given an initial velocity of 4.0m/s when it is in the equilibrium position. Accurately plot the object's position and velocity as a function of time over two periods of oscillations. Your graph should accurately the amplitudes of the position plot and the velocity plot.**

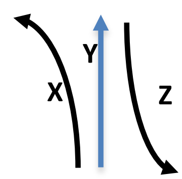


(6pts).

2. **Two strings A and B of the same length and linear density μ_A and μ_B ($\mu_A>\mu_B$) are attached to each other with string B fastened to a post. A source produces waves that travel along string A and then string B. Which of the following statements is true regarding the reflected or transmitted wave?**
   a. **The reflected wave is greater in amplitude and its wavelength is the same as the incident wave.**
   b. **The transmitted wave is smaller in amplitude and its wavelength is smaller than the incident wave.**
   c. **The reflected wave is greater in amplitude and its wavelength is smaller than the incident wave.**
   d. **The transmitted wave is smaller in amplitude and its wavelength is greater than the incident wave.**
   e. **The transmitted wave is greater in amplitude and its wavelength is greater than the incident wave.**

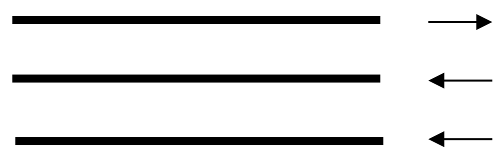
3. **If the electric field is zero in a region of space the electric potential is:**
   a. **0.** b. **constant.** c. **proportional to r.** d. **proportional to q.**

4. **The following diagram represents the paths of three different particles traveling in the plane of the paper. The magnetic field is uniform over the entire page and it is directed into the plane of this page. Which of the following statements about the particle is true?**



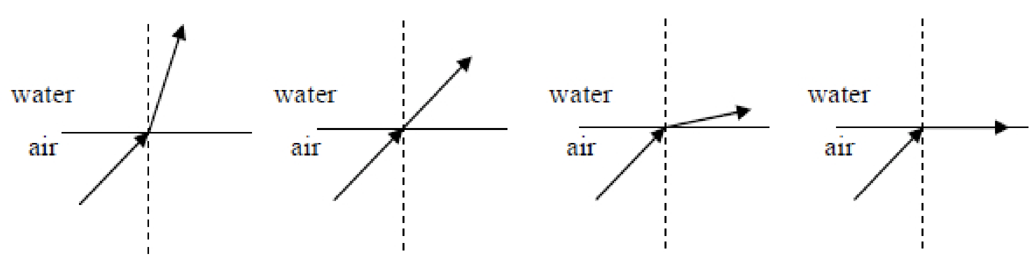
   a. **Particles X and Z are both positively charged.**
   b. **Particles X and Z are both negatively charged.**
   c. **Particle X is positively charged, whereas particle Z is negatively charged.**
   d. **Particle Z is positively charged, whereas particle X is negatively charged.**
   e. **Particle Y is negatively charged and particle X is uncharged.**
   f. **Particle Y is positively charged and particle Z is uncharged.**

5. **Three current carrying wires are equidistant from each other. The arrows indicate the direction of the current in the wires. The magnitude of the current in each wire is the same. What is the direction of the force acting on the middle wire?**



   a. **To the left**
   b. **To the right**
   c. **Toward the top of the page**
   d. **Toward the bottom of the page**
   The sum of the forces in the middle wire is zero.

6. Which shows how light moves from air into water?



(A) (B) (C) (D)

7. **Polaroid sunglasses absorb light that is polarized in what direction?**
   a. **horizontal**
   b. **vertical**

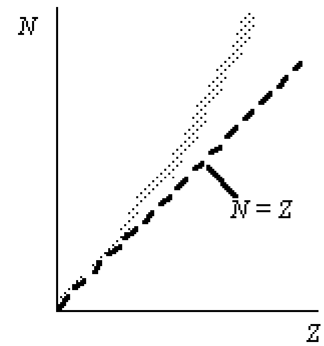
8. **When (Rubidium-87) decays via electron emission, the nucleus is transformed into**
   a. Sr b. Rb c. Kr d. Br

9. **How many neutrons are there in the ^{205}Pb $^{205}_{82}Pb$ nucleus**
   a. 82 b. 123 c. 205 d. 246 e.287

10. **A clock is moving at uniform velocity with respect to an observer. The observer, comparing things to her clock, observes that the moving clock is**
    a. **perfectly accurate**
    b. **fast**
    c. **slow**
    d. **running backwards**

Extra Question

11. **This question refers to the figure shown. Which one of the following concepts explains why heavy nuclei do not follow the N = Z line (or trend) in the figure?**
    a. **transmutation**
    b. **Coulomb repulsion**
    c. **particle-wave duality**
    d. **special theory of relativity**
    e. **Heisenberg uncertainty principle**



e,b,a,d,a,a,a, b,c,b

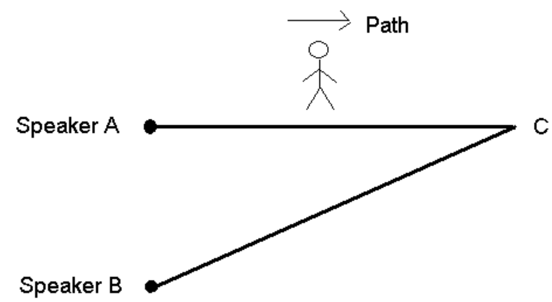
Part 2 Problems (10 points each)

Answer any eight of the ten problems. You <u>must clearly indicate</u> the problems to be graded; otherwise the first eight completed problems will be graded. Problems will be graded as no credit, half-credit, or full credit only! Please show work for full or half credit.

12. **A string of length 1.2m and mass 3.5g is stretched horizontally between two fixed points at x=0 and x=1.2m. The string is under tension of 10.0N, and is driven by a wave drive such that it vibrates at resonance frequency. What is the lowest frequency such that there is a node at x=0.24m?**
    a. 122Hz b. 145Hz c. 219Hz d. 253Hz

13. Two speakers that are in phase are simultaneously transmitting a 160 Hz tone. A person walks along the path defined by Speaker A and point C. How far from Speaker A does the person observe a first minimum in the sound intensity (destructive interference) if the speakers are 2.0m apart? Assume that the speed of sound is 340 m/s.

- **a. 2.1 m**
- **b. 1.1 m**
- **c. 1.4 m**
- **d. 2.8 m**
- **e. 3.2 m**



14. Three equivalent positive charges q=3.0μC are located at the vertices of an equilateral triangle of side of length L=9.0cm. Calculate magnitude of the force on any of the charges.

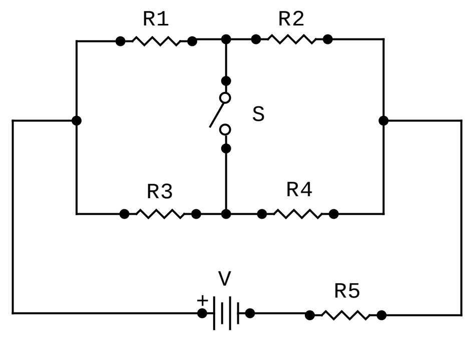
a. 17N **b. 0.0010N** **c. 1.6N** **d. 10N** **e. 0.087N**

15. A 24μF capacitor and an 8.0μF capacitor are connected in series to a 12.0V power supply. Once they are fully charged the power supply is removed and a dielectric (κ=3) is inserted between the plates of 24μF capacitor. The dielectric completely fills the space between the plates of the 24μF capacitor. What is the final voltage on the 24μF capacitor and the 8.0μF capacitor, respectively?

a. 1.0V and 9.0V **b. 3.0V and 9.0V** **c. 0.89V and 2.7V** **d. 32V and 48V**
e. 2.7V and 8.1V

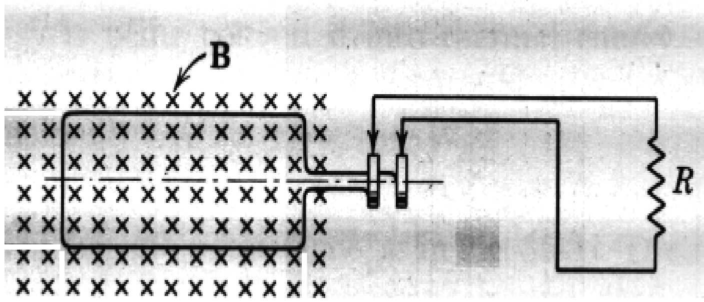
16. Consider the circuit shown below. The resistor values are R1= 72kΩ, R2=30kΩ, R3= 24kΩ, R4=20kΩ, and R5=47kΩ. What is the equivalent resistance of the circuit when the switch S is closed?

a. 7.2kΩ **b. 35 kΩ** **c. 54 kΩ** **d. 77 kΩ** **e. 156 kΩ**



17. A rectangular loop of N=100 turns and of area A=0.025m^2 is rotated at an angular frequency ω=377Hz in a uniform magnetic field B=0.25T as shown in the figure. This is the principle of the alternating current generator. A load is connected to the generator. What is the maximum counter-torque on the generator coil if R=150 ohms?

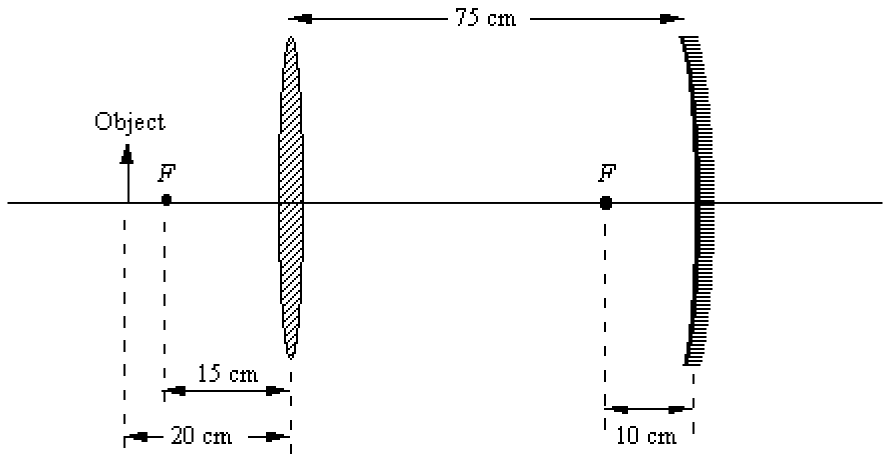
a. 0.98Nm b. 5.9Nm c. 12.3Nm d. 34.6Nm e. 236Nm



18. C$^-$ (≈12 times the mass of a proton) and C$_5^-$ ions (≈60 times the mass of the proton) are accelerated through the same potential difference. Both singly charged ions enter a region of uniform magnetic field directed perpendicular to their motion. If the magnetic field strength is 0.400T, calculate the ratio between the radii (larger radius/ smaller radius) of their circular paths. Show your work.

a. 2.24 b. 2.72 c. 3.46 d. 3.97 e. 5.59

**19. An object is placed 20 cm from a converging lens with focal length 15 cm. A concave mirror with focal length 10-cm is located 75 cm to the right of the lens as shown in the figure.
Note: The figure is not drawn to scale.**



If the height of the object is 1.0 cm, what is the height of the image?

a. 1.2 cm **b. 2.4 cm** **c. 6.0 cm** **d. 12 cm** **e. 24 cm**

20. In the fusion process,

$$ {}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n $$

$$ mass\ {}^{2}_{1}H \text{ is } 2.0141\text{u} $$

$$ mass\ {}^{3}_{1}H \text{ is } 3.0160\text{u} $$

$$ mass\ {}^{2}_{1}H \text{ is } 2.0141\text{u} $$

$$ mass\ {}^{4}_{2}He \text{ is } 4.0026\text{u} $$

$$ mass\ {}^{1}_{0}n \text{ is } 1.00867\text{u} $$

an amount of energy Q is released during the interaction. Calculate Q for this reaction.) Note 1u=931.5MeV/c^2).

a. 7.34MeV b. 12.23MeV c. 14.45Me V d. 17.54 MeV

21. A drug tagged with ^{99}Te (half-life 6.05h) is prepared for a patient. If the original activity of the sample was 1.2x10^4 Bq, what is its activity after it has sat on the shelf for 2.3h?

a. 7100Bq b.9200Bq c. 10,100Bq d. 11,300Bq

a,c,a,a,d,a,a,c,d,b

Additional Practice

1. Suppose we have four equal charges at the corners of a square of side L and a charge of the opposite sign is release from the midpoint of one of its sides. You want to calculate the speed of the charge after it has traveled distance L/2. Why can't you apply Newton's 2nd law and our kinematic equations to determine the speed?
2. When an electron (or any negatively charged particle) speeds up in an electric field does is move in the direction of increasing potential energy or decreasing potential energy? Repeat for a proton or any positively charged particle.
3. When an electron (or any negatively charged particle) slows down in an electric field does is move in the direction of increasing potential energy or decreasing potential energy? Repeat for a proton or any positively charged particle.
4. When does a concave mirror produce real images? Repeat for the convex lens, convex mirror, and concave lens.
5. What do the following mean: critical angle, Brewster's angle, Snell's law, the law of Reflection, and the Rayleigh criterion?
6. List 10 different vector quantities (along with SI units) that you learned in 2A and 2B.
7. Can you calculate the percent error or percent difference in an experiment to the correct number of significant figures?
8. List five facts about the electric field, electric charge, and/ or electric potential for a conductor in electrostatic equilibrium.
9. How many significant figures does your basic meter-stick and triple-beam balance give you?
10. What is the difference between the significant figure rule for adding and dividing?
11. What is Hooke's Law? What is the work done by a spring when it is stretched by a distance x?
12. What happens to the energy stored in an isolated charged capacitor when a dielectric is inserted into it? Why does it change? Repeat the previous questions, but this time assume that the capacitor is still connected a power supply when the dielectric is inserted into the capacitor.
13. Compare how capacitors and resistor combine in series and parallel.
14. Discuss the concept of interference for mechanical waves and electromagnetic waves. What are the conditions for constructive and destructive interference in each case? Can you produce the analog of the double slit experiment with sound waves? Give an example.
15. If the intensity of a sound wave doubles, what happens to the intensity level? Does it double? What if the intensity level doubles what happened to the intensity to produce this effect.
16. At what frequency are your ears most sensitive.
17. Compare and contract transverse and longitudinal waves. What are the effects that are occur (*e.g.* reflection, diffraction *etc*) with transverse waves but don't occur with longitudinal waves?
18. Compare and contrast simple harmonic motion with oscillatory motion.
19. Does the magnetic field do work on charged particles? What is the direction of the force on a charged particle relative to its direction of motion, and the direction of the magnetic field? What is required on a charged particle if it is to experience a force due to a magnetic field? What about an electric field.
20. Compare the properties of electric field lines with magnetic field lines.
21. How do you determine the magnitude and direction of the force on a wire in a magnetic field? What about the torque on a loop of wire in a magnetic field?
22. How does the motor work? What principles are involved? Repeat for a generator.
23. Discuss Faraday's Law and Lenz's law.
24. Compare and contrast AC and DC current. What is required to cause charge move through a wire?
25. A person that is 2.0m tall is moving upward in a very fast elevator (near the speed of light). The walls of the elevator are made of transparent material. At the same time in an adjacent elevator another

2.0m tall person is moving downward at high speed. When they pass each other, each person says that the person in the adjacent elevator is shorter than them. Who is correct?

26. An earthworm has eight hearts located in different parts of its body. The eight hearts must all beat at the same time in order to produce effective blood circulation. If the earthworm moves past us at $v=3/5c$, we observe its front hearts to be out of synch with its rear hearts. Does it mean that the worm is dying?
27. Discuss the properties of the nucleus.
28. What are the types of nuclear decay? Give an example of each. Don't forget to write the reaction formula.
29. Compare nuclear fission to nuclear fusion? Give some examples.
30. What is carbon dating? What are possible pitfalls with carbon dating and how one can correct for them?
31. When and why does the nucleus become unstable?

$$\left|\vec{F}_{\text{point charge}}\right| = \frac{k|q_1||q_2|}{r^2} \;;\quad \left|\mathrm{E}_{\text{point charge}}\right| = \frac{k|q|}{r^2} \qquad \vec{E} = \frac{\vec{F}}{q_o}$$

$$\Delta U = \Delta PE = -W_{FIELD} = -F_{FIELD}d = -q_o Ed = q_o \Delta V$$

$$\Delta V = -Ed \;\; for\ uniform\ fields$$

$$\mathrm{V}_{\text{point charge}} = \frac{\mathrm{kq}}{\mathrm{r}}\text{; assuming } \mathrm{V} = 0 \text{ at infinity}$$

$$\mathrm{U{=}PE}_{\text{point charge}} = \frac{kq_1q_2}{r}\text{; assuming } \mathrm{PE} = 0 \text{ at infinity}$$

$$Q = C\Delta V \qquad C_{parallel\ plate} = \frac{\varepsilon_o A}{d}$$

$$C_{eq} = C_1 + C_2 + C_3 + \ldots \qquad \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$$

$$Energy = \frac{1}{2}CV^2 = Q^2/2C = QV/2$$

$$C' = \kappa C = \frac{\kappa\varepsilon_o A}{d}$$

$$\Delta x = x - x_o = v_{ox}t + 1/2a_x t^2 \qquad v_{f_x} = v_{i_x} + a_x t$$

$$v_{f_x}^2 = v_{i\,x}^2 + 2a_x\Delta x \qquad v_{avg} = \frac{\Delta x}{\Delta t} = \frac{1}{2}\left(v_{f_x} + v_{i_x}\right)$$

$$a_r = \frac{v_T^2}{r}$$

$$Period = \mathrm{T} = \mathrm{f}^{-1} = 2\pi/\omega \qquad \mathrm{f} = \text{frequency}$$

$$\left|\vec{F}_{centripetal}\right| = \frac{mv^2}{r}r$$

$$\vec{F} = m\vec{a}$$

$$\Delta\mathrm{PE}+\Delta\mathrm{KE}=0 \text{ Conservation of Energy}$$

$$\Delta\mathrm{PE}+\Delta\mathrm{KE}=\mathrm{W}_{\mathrm{nc}} \; or \; \mathrm{W}_{\mathrm{nc}} = \Delta U + \Delta\mathrm{KE}$$

$$|\vec{\tau}| = rF\sin\theta$$

$$R = \rho L/A$$

$$\rho = \rho_o\left[1+\alpha(T-T_o)\right]; \qquad R = R_o\left[1+\alpha(T-T_o)\right]$$

$$V = IR; \qquad P = \frac{V^2}{R} = VI = I^2R \qquad I = \Delta Q/\Delta t$$

$$R_{eq} = R_1 + R_2 + R_3 + \ldots$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

$$Q_{RC} = Q_o\left(1 - e^{-\frac{t}{RC}}\right); \quad V_{RC} = V_o\left(1 - e^{-\frac{t}{RC}}\right);$$

$$Q_o = CV_o$$

$$I_{RC} = I_o e^{-\frac{t}{RC}}; \qquad Q_{discharge} = I_{discharge}e^{-\frac{t}{RC}};$$

$$\left|\vec{F}_{charge}\right| = q|\vec{v}|\left|\vec{B}\right|\sin\theta \qquad \left|\vec{F}_{wire}\right| = ILB\sin\theta$$

$$\left|\vec{B}_{wire}\right| = \frac{\mu_o I}{2\pi R} \qquad \left|\vec{B}_{,loop}\right| = \frac{\mu_o I}{2R}$$

$$\left|\vec{B}_{,solenoid}\right| = \frac{\mu_o NI}{L} = \mu_o nI$$

$$|\vec{\tau}| = rF\sin\theta = NAIB\sin\theta = |\vec{\mu}|\left|\vec{B}\right|\sin\theta$$

$$\Phi = BA\cos\theta \qquad \Phi_{GENERATOR} = NAB\cos\omega t$$

$$EMF_{induced} = -N\frac{\Delta\Phi}{\Delta t}$$

$$\left|EMF_{motional}\right| = \left|\vec{B}\right|L|\vec{v}|$$

$$EMF_{GENERATOR} = NAB\omega\sin\omega t$$

$$c = f\lambda \qquad \frac{E}{B} = c$$

$$I = \frac{E_{\max}B_{\max}}{2\mu_o} = \frac{E_{\max}^2}{2\mu_o c} = \frac{c}{2\mu_o}B_{\max}^2$$

$$p_{reflection} = \frac{2U}{c} \qquad p_{absorption} = \frac{2U}{c}$$

$$f_O = f_S\left(1 \pm \frac{u}{c}\right) if\ \ u << c$$

$$\left|\vec{F}_{\text{point charge}}\right| = \frac{k|q_1||q_2|}{r^2} \;;\quad \left|\mathrm{E}_{\text{point charge}}\right| = \frac{k|q|}{r^2} \qquad \vec{E} = \frac{\vec{F}}{q_o}$$

$$\Delta PE = -W_{FIELD} = -F_{FIELD}d = -q_o Ed = q_o\Delta V$$

$$\Delta V = -Ed \;\; for\ uniform\ fields$$

$$\mathrm{PE}_{\text{point charge}} = \frac{kq_1q_2}{r}\text{; assuming } \mathrm{PE} = 0 \text{ at infinity}$$

$$\Delta x = x - x_o = v_{ox}t + 1/2a_x t^2 \qquad v_{f_x} = v_{i_x} + a_x t$$

$$v_{f_x}^2 = v_{i\,x}^2 + 2a_x\Delta x \qquad v_{avg} = \frac{\Delta x}{\Delta t} = \frac{1}{2}\left(v_{f_x} + v_{i_x}\right)$$

$$a_r = \frac{v_T^2}{r} \qquad \vec{F} = m\vec{a} \qquad \left|\vec{F}_{centripetal}\right| = \frac{mv^2}{r}$$

$$Period = \mathrm{T} = \mathrm{f}^{-1} = 2\pi/\omega \qquad \mathrm{f} = \text{frequency}$$

$$\Delta\mathrm{PE} + \Delta\mathrm{KE} = 0 \text{ Conservation of Energy}$$

$$\Delta\mathrm{PE} + \Delta\mathrm{KE} = \mathrm{W}_{\mathrm{nc}} \qquad KE = \frac{1}{2}mv^2$$

$$Power = P = \frac{\Delta W}{\Delta t} = \left|\vec{F}\right||\vec{v}|$$

$F_{SPRING} = -kx$

$ma = -kx \Rightarrow a = -\frac{k}{m}x = -\omega^2 x$

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

$T_{Pendulum} = 2\pi\sqrt{\frac{L}{g}} = \frac{1}{f} = \frac{2\pi}{\omega}$

$x = A\cos(\omega t); \quad v = -A\omega\sin\omega t; \quad a = -A\omega^2\cos(\omega t)$

$K = \frac{1}{2}mv^2; \quad U_S = \frac{1}{2}kx^2; \quad U_g = mgh; \quad \sum\vec{F} = m\vec{a} \quad ;$

$E = PE + KE; \quad \Delta PE + \Delta KE = 0; \quad W_{nc} = \Delta PE + \Delta KE$

$v = f\lambda; \quad v = \sqrt{\frac{F}{\mu}}; \quad k = 2\pi/\lambda; \quad \omega = vk$

$P_{avg} = \frac{1}{2}\sqrt{\mu F}\omega^2 A^2 = \frac{1}{2}\mu v\omega^2 A^2; \quad I_{avg} = \frac{P}{4\pi r^2}; \quad \frac{I_2}{I_1} = \left(\frac{r_1}{r_2}\right)^2$

$v = \sqrt{\frac{B}{\rho}}; \quad v_{rod} = \sqrt{\frac{Y}{\rho}}; \quad v_{gas} = \sqrt{\frac{\gamma RT}{M}}; \quad v_{air} = 331.5 + 0.607T_C$

$\beta = 10\log(I/I_o); \qquad I_o = 10^{-12}W/m^2$

$f' = f\left(\frac{v \pm v_{obs}}{v \mp v_{source}}\right)$

$f_n = nf_1 = n\frac{v}{2L} \quad n = 1,2,3... \qquad f_n = nf_1 = n\frac{v}{4L} \quad n = 1,3,5...$

$\Delta x = \lambda/2; \qquad \Delta x = \lambda$

$Power = P = \frac{\Delta W}{\Delta t} = |\vec{F}||\vec{v}|$

$$\gamma = \frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}}; \Delta t = \gamma\Delta t_{proper}; L = \frac{L_{proper}}{\gamma}$$

$$p = \gamma mv; E = \gamma mc^2; KE = (\gamma - 1)mc^2$$

$$E^2 = (pc)^2 + (mc^2)^2$$

$$R = \left|\frac{\Delta N}{\Delta t}\right| = \lambda N; N = N_o e^{-\lambda t}; \quad \lambda = \frac{\ln 2}{t_{1/2}}$$

$$KE = \left(1 + \frac{m}{M}\right)|Q|$$

k=8.99x10^{9}Nm^2/C^2=1/(4$\pi\varepsilon_o$)

μ_o=4πx10^{-7}Tm/A

ε_o=8.85x10^{-12}C^2/Nm^2

1μC=10^{-6}C=10^{3}nC=10^{6}pC

m$_p$=1.67x10^{-27}kg; m$_e$=9.11x10^{-31}kg

e=1.60x10^{-19}C

1eV=1.60x10^{-19}J

1μF=10^{-6}F; 1nF=10^{-9}F

1kWh=3.60x10^{6}J/s

V$_{sphere}$=4/3πr^3; A$_{sphere}$=4πr^2;

A$_{Circle}$=πr^2; Circumference=2πr

$\theta_i = \theta_{reflected}$

$n_1\sin\theta_1 = n_2\sin\theta_2; \quad n = c/v; \quad \lambda_n = \lambda_{vacuum}/n$

$\sin\theta_{critical} = \frac{n_{final}}{n_{initial}}, \quad where \qquad n_{final} < n_{initial}$

$\tan\theta_{brewster} = \frac{n_{final}}{n_{initial}}$

$I = I_{\max}\cos^2\theta$

$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}; \quad M = -\frac{s_i}{s_o}; \quad f_{mirror} = \pm\frac{R}{2}$

$diopters = \frac{1}{f}$

$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$M_{mag} = \frac{25}{f}; \quad M_{miscoscope} = \frac{(L - f_e)25}{f_e f_o};$

$M_{telescope} = \frac{f_{objective}}{f_{eyepiece}}$

$d\sin\theta = m\lambda; \quad m = 0.\pm1,\pm2,\pm3...$

$d\sin\theta = (m + 1/2)\lambda; \quad m = 0.\pm1,\pm2,\pm3...$

$y_{brught} = L\tan\theta \approx L\sin\theta = Lm\lambda/d$

$y_{dark} = L\tan\theta \approx L\sin\theta = L(m+1/2)\lambda/d$

$\phi = \frac{2\pi}{\lambda}(L_2 - L_1)$

$2t = m\lambda_n \ or \ 2t = (m+1/2)\lambda_n$

$a\sin\theta = m\lambda; \quad m = \pm1,\pm2,\pm3...$

$\sin\theta = 1.22\frac{\lambda}{D} \qquad R = \frac{\lambda}{\Delta\lambda}$