Last Name:________________First Name_________________NetID_______________
Discussion Section:________Discussion TA Name:______________________________

Instructions—
Turn off your cell phone and put it away.
Keep your calculator on your own desk. Calculators may not be shared.
This is a closed book exam. You have ninety (90) minutes to complete it.

1. Use a #2 pencil; do **not** use a mechanical pencil or a pen. Fill in completely (until there is no white space visible) the circle for each intended input – both on the identification side of your answer sheet and on the side on which you mark your answers. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner.

2. Print your last name in the **YOUR LAST NAME** boxes on your answer sheet and print the first letter of your first name in the **FIRST NAME INI** box. Mark (as described above) the corresponding circle below each of these letters.

3. Print your NetID in the **NETWORK ID** boxes, and then mark the corresponding circle below each of the letters or numerals. Note that there are different circles for the letter "I" and the numeral "1" and for the letter "O" and the numeral "0". **Do not** mark the hyphen circle at the bottom of any of these columns.

4. You may find the version of **this Exam Booklet at the top of page 2**. Mark the **version** circle in the **TEST FORM** box in the bottom right of your answer sheet. **DO THIS NOW!**

5. Do not write in or mark the circles in any of the other boxes (STUDENT NUMBER, DATE, SECTION, SCORES, SPECIAL CODE).

6. Sign your name **(DO NOT PRINT)** on the **STUDENT SIGNATURE** line.

7. On the **SECTION** line, print your **DISCUSSION SECTION**. You need not fill in the COURSE or INSTRUCTOR lines.

Before starting work, check to make sure that your test booklet is complete. You should have 10 ***numbered pages*** *plus two Formula Sheets at the end.*

*Academic Integrity—***Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including expulsion.**

This Exam Booklet is Version A. Mark the **A** circle in the **TEST FORM** box in the bottom right of your answer sheet. **DO THIS NOW!**

Exam Grading Policy—

The exam is worth a total of 111 points, composed of two types of questions.

MC5: *multiple-choice-five-answer questions, each worth 6 points.*
Partial credit will be granted as follows.

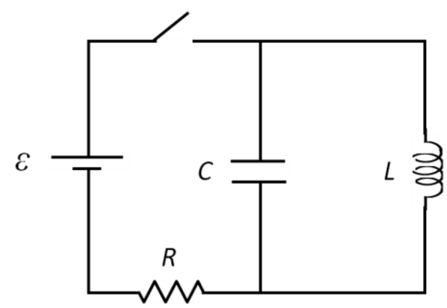
(a) If you mark only one answer and it is the correct answer,
you earn **6** points.
(b) If you mark *two* answers, one of which is the correct answer,
you earn **3** points.
(c) If you mark *three* answers, one of which is the correct answer,
you earn **2** points.
(d) If you mark no answers, or more than *three*, you earn 0 points.

MC3: *multiple-choice-three-answer questions, each worth 3 points.*
No partial credit.

(a) If you mark only one answer and it is the correct answer,
you earn **3** points.
(b) If you mark a wrong answer or no answers, you earn **0** points.

The next two questions pertain to the following situation.

A circuit consists of a battery, a resistor, a capacitor, and an inductor as shown. The values of the circuit elements are: $\varepsilon = 24$ V, $R = 15\ \Omega$, $C = 125\ \mu$F, and $L = 250$ mH. The switch has been closed for a long time when at $t = 0$, the switch is opened.



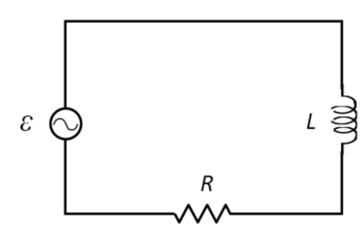
1. What is Q_{max}, the maximum charge on the capacitor for $t > 0$?

a. $Q_{max} = 1.4$ mC
b. $Q_{max} = 1.7$ mC
c. $Q_{max} = 3.5$ mC
d. $Q_{max} = 8.9$ mC
e. $Q_{max} = 57$ mC

2. Which of the following statements is <u>not</u> true for $t > 0$?

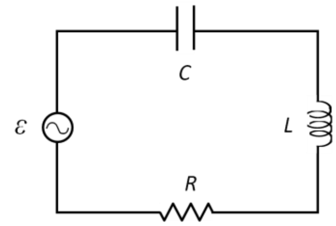
a. The voltage drop across the capacitor is always equal to that across the inductor.
b. The energy stored in the capacitor is always equal to that in the inductor.
c. The maximum voltage across the inductor is larger than the battery voltage.

3. A circuit consists of an AC generator, a resistor, and an inductor as shown. Which of the following statements is true?



a. The generator voltage lags the current.
b. The current leads the voltage across the inductor.
c. The maximum current increases as the generator frequency decreases.

The next three questions pertain to the following situation.

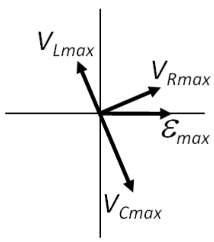


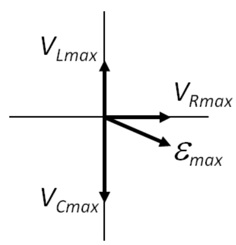
A circuit consists of an AC generator, a resistor, a capacitor, and an inductor as shown. The generator voltage lags the current by 30 degrees and is given as $\varepsilon = 115\sin(2\pi ft)$ Volts, where $f = 60$ Hz. The peak current is 0.25 A and the maximum voltage across the inductor is 150 V.

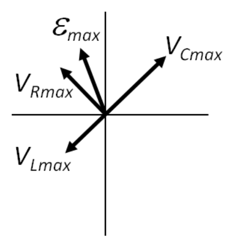
4. What is X_C, the capacitive reactance?

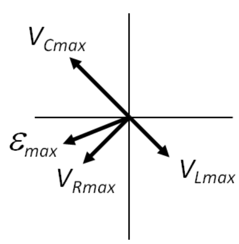
a. $X_C = 830\ \Omega$
b. $X_C = 760\ \Omega$
c. $X_C = 866\ \Omega$
d. $X_C = 980\ \Omega$
e. $X_C = 998\ \Omega$

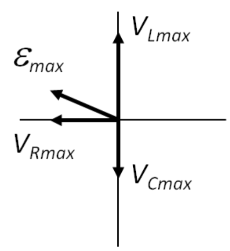
5. Which of the following voltage phasor diagrams is the correct one when <u>$t = 5.6$ ms</u>?

(a)


(b)


(c)


(d)


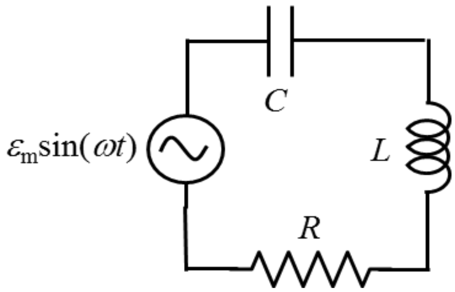
(e)


6. How should the generator frequency be changed in order to put the circuit at resonance?

a. Such frequency does not exist.
b. It should be decreased.
c. It should be increased.

The next two problems are related to the following situation:

An AC generator with a peak voltage of $\varepsilon_m = 120$ V is connected in series with a resistor, capacitor, and inductor as shown. It is known that the total impedance of the circuit is 600 Ohms and that the voltage across the generator <u>leads</u> the current in the circuit by an angle less than 90 degrees. At time $t = 0$, it is found that the magnitude of the voltage across the inductor is 50 V and the magnitude of the voltage across the capacitor is 30 V.



7. By <u>what factor</u> should the generator's angular frequency ω be multiplied to bring the circuit into resonance?

a. 1.67
b. 0.77
c. 0.60
d. 1.30
e. 0.20

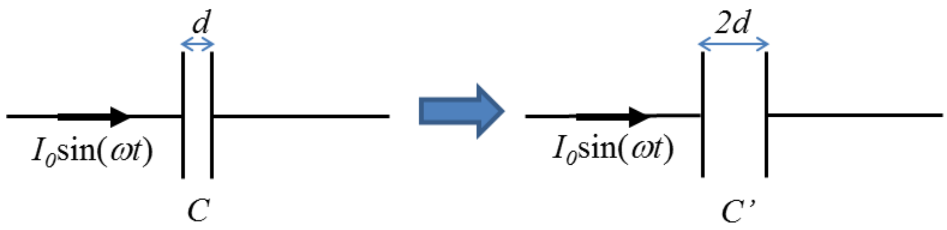
8. What is the average power delivered to the circuit when it is on resonance?

a. 10.4 W
b. 24.0 W
c. 12.0 W

9. Consider two AC circuits, each composed of a generator, capacitor, inductor, and resistor connected in series, and each operating at resonance. For circuit 1, the inductance is 200 mH, the peak current is 5 A, and the energy dissipated during one cycle is 0.5 J. For circuit 2 the inductance is 300 mH, the peak current is 1 A, and the energy dissipated during one cycle is 0.8 J. Find the ratio of the Q-factors for circuits 1 and 2, Q_1/Q_2.

a. $Q_1/Q_2 = 0.6$
b. $Q_1/Q_2 = 1.5$
c. $Q_1/Q_2 = 27$
d. $Q_1/Q_2 = 16$
e. $Q_1/Q_2 = 1.1$

10. Consider a capacitor having plates of area *A* separated by a distance *d*, connected to an AC current source as shown. If I double the separation between the capacitor plates, as depicted below, what happens to the peak electric and magnetic fields between the plates? (Assume in both cases $A >> d^2$).



a. The peak electric field remains constant and the peak magnetic field remains constant.
b. The peak electric field decreases and there is still no magnetic field.
c. The peak electric field remains constant and the peak magnetic field decreases.

11. A monochromatic plane electromagnetic wave with a wavelength λ = 550 nm is propagating in vacuum in the –*x*-direction. The electric field for this wave could be described by which of the following equations:

a. $\vec{E} = E_0 \sin[(1.14 \times 10^7)x + (3.43 \times 10^{15})t]\,\hat{x}$
b. $\vec{E} = E_0 \sin[(2.24 \times 10^6)x + (7.81 \times 10^{12})t]\,\hat{y}$
c. $\vec{E} = E_0 \sin[(2.24 \times 10^6)x - (7.81 \times 10^{12})t]\,\hat{y}$
d. $\vec{E} = E_0 \sin[(1.14 \times 10^7)x + (7.81 \times 10^{12})t]\,\hat{x}$
e. $\vec{E} = E_0 \sin[(1.14 \times 10^7)x + (3.43 \times 10^{15})t]\,\hat{y}$

12. Consider an electromagnetic plane wave propagating in the +z-direction which at a particular moment in space has an electric field given by $\vec{E} = 108$ V/m $(\hat{x} + \hat{y})$. What is the value of the magnetic field at this same time and place?

a. $\vec{B} = 3.6 \times 10^{-7} T(\hat{x} - \hat{y})$
b. $\vec{B} = 108\, T(-\hat{x} - \hat{y})$
c. $\vec{B} = 3.6 \times 10^{-7} T(-\hat{x} + \hat{y})$
d. $\vec{B} = 3.2 \times 10^{-10} T(-\hat{x} + \hat{y})$
e. $\vec{B} = 3.2 \times 10^{-10} T\,(\hat{x} + \hat{y})$

13. Suppose that the magnetic field of an electromagnetic wave is given by $\vec{B}(x, y, z, t) = B_0 \sin(kz + \omega t)\hat{x}$, with $B_0 = 3\ \mu T$. What is the maximum energy density that this wave achieves?

a. 7.17×10^{-6} J/m^3
b. 3.58×10^{-6} J/m^3
c. 1.19 J/m^3
d. 3.58×10^{6} J/m^3
e. 7.16×10^{6} J/m^3

14. Consider a transformer that steps an initial voltage of 1500 V across the primary coil down to a voltage of 110 V across the secondary coil. What is the ratio of the currents in the primary and secondary coils, I_p/I_s?

a. 3.69
b. 13.6
c. 0.073

15. In 1929, Edwin Hubble made the observation reproduced in the graph below. The *x*-axis is the estimated distance to a galaxy, and the *y*-axis is the apparent radial velocity; that is, the velocity in the *r*-direction with the Earth at the center of the coordinate system. What did Hubble see in his telescope to make this discovery?

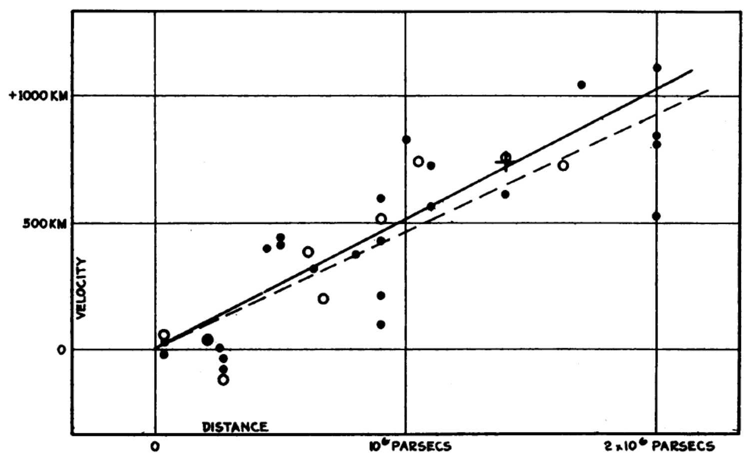


FIGURE 1
Velocity-Distance Relation among Extra-Galactic Nebulae.

a. The frequency of light from far off galaxies is **larger** than that from close galaxies.
b. The frequency of light is not dependent on how far galaxies are from the Earth.
c. The frequency of light from far off galaxies is **smaller** than that from close galaxies.

The next three questions pertain to the following situation:

Suppose that there is an electromagnetic wave with electric field $\vec{E}(x,y,z,t) = (E_x\hat{x} + E_y\hat{y})\cos(kz + \omega t)$ where $E_x = 4.5\frac{V}{m}, E_y = 7.5\frac{V}{m}$.

16. What is the polarization angle θ of this wave? [Assume $\theta = 0$ when the wave is polarized in the *x*-direction.]

a. 64^o
b. 93^o
c. 59^o

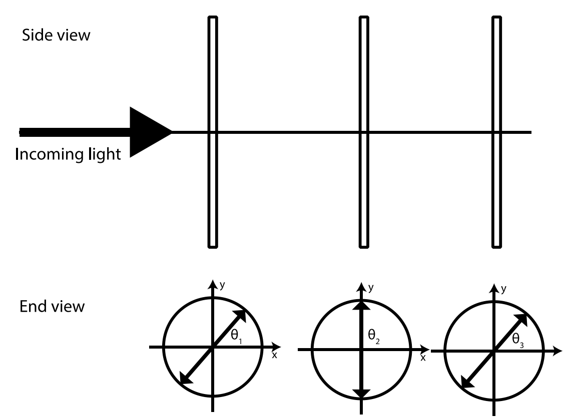
17. What is the Poynting vector of this wave?

a. $-\frac{E_x^2+E_y^2}{c\mu_0}\ \hat{z}$
b. $E_x^2\hat{x} + E_y^2\hat{y}$
c. $\frac{E_x^2+E_y^2}{c\mu_0}\ \hat{x}$
d. $\frac{E_x^2+E_y^2}{c\mu_0}\ \hat{z}$
e. $-\frac{E_x^2+E_y^2}{\mu_0}\ \hat{x}$

18. Suppose the wave is incident on a quarter wave plate, which is oriented so that its slow axis is aligned with the $\hat{y}$-direction and its fast axis is aligned with the $\hat{x}$-direction. What is the polarization of the light after it exits the quarter wave plate?

a. Horizontally polarized
b. Circularly polarized
c. Neither of the above

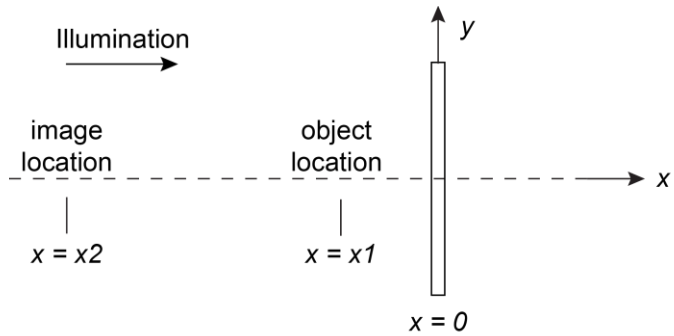
19. Initially <u>unpolarized</u> light with intensity 75 mW/m^2 is passed through three polarizing filters, as shown in the figure. The angles between the transmission axis and the *x*-axis are as follows: $\Theta_1 = \Theta_3 = 40^o, \Theta_2 = 90^o$. What is the intensity of the light after it exits the third filter?



a. 0.0 mW/m^2
b. 3.8 mW/m^2
c. 75.0 mW/m^2
d. 15.5 mW/m^2
e. 6.4 mW/m^2

The next two questions pertain to the situation described below:

An object is located at $x = x_1$ in front of a lens. The object is illuminated from the direction shown. The image produced by the lens is located at $x_2 = -180$ cm. The lens produces a magnification of $m = 3$.



20. What is the focal length of the lens?

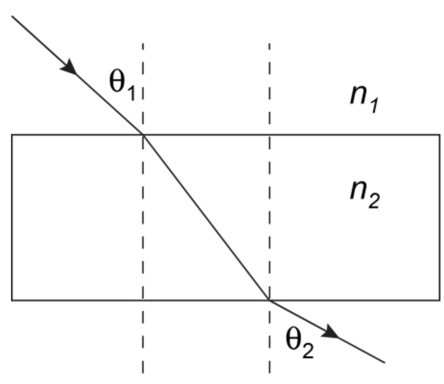
a. $f = -60$ cm
b. $f = 90$ cm
c. $f = 60$ cm
d. $f = -90$ cm
e. There is not enough information given

21. What kind of image is produced by the lens?

a. virtual and upright
b. virtual and inverted
c. real and upright

The next two questions pertain to the situation described below

A beam of light is incident on a transparent block with index of refraction n_2. The medium surrounding the block has an index of refraction $n_1 = 1.4$. The beam makes an angle of incidence θ_1 with respect to the surface normal. The beam exits the block making an angle θ_2 with respect to the surface normal.



22. How does the angle θ_2 depend on θ_1?

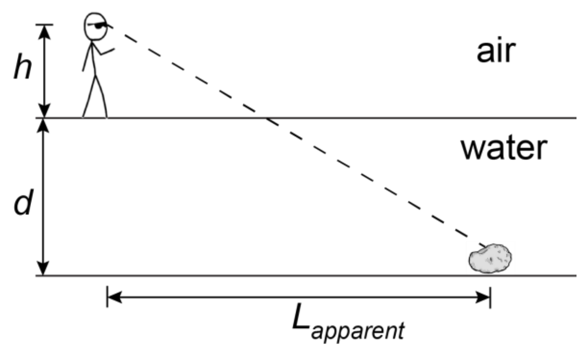
a. If $n_2 > n_1$, then $\theta_2 > \theta_1$.
b. If $n_2 > n_1$, then $\theta_1 > \theta_2$.
c. $\theta_2 = \theta_1$.

23. We observe that for $\theta_1 > 63°$, the beam reflects completely from the top surface of the block. What is the index of refraction of the block?

a. $n_2 = 1.37$
b. $n_2 = 1.25$
c. $n_2 = 1.45$

The next two questions pertain to the situation described below:

A person is standing on a platform and looking at a small rock at the bottom of a lake. The height from the ground to the man's eyes is h = 1.8 m. From where he is standing, the rock appears to be located $L_{apparent}$ = 6 m in front of him. The lake is d = 3 m deep; the index of refraction of the air and water are n_{air} = 1 and n_{water} = 1.33, respectively.



24. What is the <u>actual</u> distance of the rock from the person, L_{rock}?

a. L_{rock} = 6.0 m
b. L_{rock} = 4.4 m
c. L_{rock} = 5.3 m
d. L_{rock} = 7.2 m
e. L_{rock} = 3.4 m

25. If we replace the water in the lake with another medium, which has an index of refraction closer to that of air, then

a. $L_{apparent}$ will not change.
b. $L_{apparent}$ will increase.
c. $L_{apparent}$ will decrease.

Check to make sure you bubbled in all your answers.
Did you bubble in your name, exam version and network-ID?

Physics 212 Formula Sheet –2014

Mechanics:

$$K = \frac{1}{2} m\text{v}^2 \qquad a_c = \frac{\text{v}^2}{r}$$

Electrostatics:

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r_{12}^{\ 2}} \hat{r}_{12} \qquad \vec{E} \equiv \frac{\vec{F}}{q_0} \qquad \Phi_E = \int \vec{E} \cdot d\vec{S} \qquad \oint \vec{E} \cdot d\vec{S} = \frac{Q_{encl}}{\varepsilon_0}$$

$$\vec{E} = -\vec{\nabla} V \qquad V_B - V_A \equiv \frac{W_{AB}}{q_0} = -\int_A^B \vec{E} \cdot d\vec{l} \qquad \Delta U_{AB} = -W_{AB}$$

Capacitors and RC Circuits:

$$C \equiv \frac{Q}{V} \qquad C_0 = \frac{\varepsilon_0 A}{d} \qquad C = \kappa C_0 \qquad U = \tfrac{1}{2} CV^2 = \tfrac{1}{2} \frac{Q^2}{C} \qquad u_E = \frac{1}{2} \varepsilon_0 E^2$$

$$C = C_1 + C_2 \qquad \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} \qquad \tau = RC \qquad V = V_0 e^{-t/\tau} \qquad V = V_\infty (1 - e^{-t/\tau})$$

Simple Circuits:

$$R = \frac{V}{I} \qquad R = \frac{\rho L}{A} \qquad \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \qquad R = R_1 + R_2$$

$$P = IV = I^2 R$$

Magnetostatics:

$$\vec{F} = q\vec{E} + q\vec{\text{v}} \times \vec{B} \qquad d\vec{F} = Id\vec{l} \times \vec{B} \qquad d\vec{B} = \frac{\mu_0}{4\pi} \frac{Id\vec{l} \times \hat{r}}{r^2} \qquad \oint \vec{B} \cdot d\vec{l} = \mu_0 I$$

$$\vec{\mu} = NI\vec{A} \qquad \vec{\tau} = \vec{\mu} \times \vec{B} \qquad U = -\vec{\mu} \cdot \vec{B}$$

Induction and RL Circuits:

$$EMF = -\frac{d\Phi_B}{dt} \qquad \Phi_B = \int \vec{B} \cdot d\vec{S} \qquad L \equiv \frac{\Phi_B}{I} \qquad V = L\frac{dI}{dt} \qquad \tau = \frac{L}{R}$$

$$U = \frac{1}{2} LI^2 \qquad u_B = \frac{1}{2} \frac{B^2}{\mu_0} \qquad V = V_0 e^{-t/\tau} \qquad V = V_\infty (1 - e^{-t/\tau})$$

LC, LCR, and AC Circuits:

$$\omega_0 = \frac{1}{\sqrt{LC}} \qquad X_C \equiv \frac{1}{\omega C} \qquad X_L \equiv \omega L$$

$$Z \equiv \sqrt{R^2 + (X_L - X_C)^2} \qquad \varepsilon_{\max} = I_{\max} Z \qquad \varepsilon_{rms} = \frac{1}{\sqrt{2}}\varepsilon_{\max} \qquad V_2 = \frac{N_2}{N_1}V_1$$

$$< P >= \frac{1}{2}\varepsilon_{\max} I_{\max}\cos\phi = I_{rms}^2 R \qquad Q = \frac{\omega_0 L}{R} \approx \frac{\omega_0}{FWHM}$$

EM Waves, Polarization, Reflection and Refraction:

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I + \mu_0 I_D \qquad I_D = \varepsilon_0 \frac{d\phi_E}{dt} \qquad Z_0 = 377\Omega$$

$$\vec{S} \equiv \frac{\vec{E}\times\vec{B}}{\mu_0} \qquad E = cB \qquad u = u_E + u_B \qquad Intensity = \frac{\langle P\rangle}{area} = c\langle u\rangle = \frac{1}{2}\frac{E_{\max}^2}{Z_0}$$

$$\omega = 2\pi \mathrm{f} \qquad \mathrm{v} = \lambda f = \frac{\omega}{k} \qquad Intensity_2 = Intensity_1 \cos^2(\theta_1 - \theta_2)$$

$$\mathrm{v} = c/n \qquad n_1 \sin\theta_1 = n_2 \sin\theta_2 \qquad \sin\theta_c = \frac{n_2}{n_1} \qquad f' = f\sqrt{\frac{1\pm \mathrm{v/c}}{1\mp \mathrm{v/c}}}$$

Mirrors and lenses:

$$f = \frac{R}{2} \qquad \frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \qquad \frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \qquad m = -\frac{s'}{s}$$

Important Constants:

$$k \equiv \frac{1}{4\pi\varepsilon_\circ} = 8.99\times10^9 \ \frac{\mathrm{Nm}^2}{\mathrm{C}^2} \qquad \varepsilon_0 = 8.85\times10^{-12}\frac{C^2}{Nm^2} \qquad \frac{\mu_0}{4\pi} \equiv 1\times10^{-7} \ \frac{\mathrm{N}}{\mathrm{A}^2} = 1\times10^{-7}\,{T_m}/{A}$$

$$c = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = 3\times10^8 \mathrm{m/s} \qquad e = 1.60\times10^{-19}\ \mathrm{C} \qquad Z_0 = \mu_0 c = 377\,\Omega$$

SI Prefixes

Power	Prefix	Symbol
10^6	mega	M
10^3	kilo	k
10^0	—	—
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

Geometry

Circle

area $= \pi R^2$

circumf. $= 2\pi R$

Sphere

area $= 4\pi R^2$

volume $= \frac{4}{3}\pi R^3$

$$\vec{\nabla} V = \hat{x}\frac{\partial V}{\partial x} + \hat{y}\frac{\partial V}{\partial y} + \hat{z}\frac{\partial V}{\partial z}$$