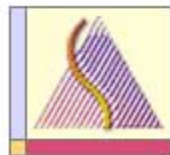




uOttawa

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Canada's university

Principles of Physics II
PHY1322



Department of
Physics

Instructor: Dr. Andrzej Czajkowski
Final Exam
April 17 2014

Closed book exam
Duration: 3 hrs
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April 2014

Final Exam: 3 hrs

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PARTICLE PHYSICS and ASTROPHYSICS/COSMOLOGY NUCLEAR PHYSICS

- 1 E Which force is mediated by W and Z bosons?
a) The weak force
b) The electromagnetic force
c) The gravitational force
d) The strong force
e) The coulomb force
- 2E Mesons consist of
a) three quarks.
b) one quark and one antiquark.
c) three antiquarks.
d) two antiquarks and one quark.
e) two quarks and one antiquark.
- 3E White dwarf
a) is a star that no longer produces radiation
b) is star that produces radiation predominantly via H→He synthesis
c) is a star that produces radiation via cooling
d) is a type of neutron star
e) none of the above
- 4E The radius of a nucleus of ${}_{67}^{165}\text{Ho}$ (in fm) is
a. 15.4 b. 5.5 c. 12.8 d. 6.6 e. none of the above
- 5E Heavy nuclei are unstable because
a. each nucleon is a separate particle that is not acted on by the nuclear force.
b. there are not enough protons present relative to the number of neutrons for the electrical force to be strong enough.
c. the nuclear force dominates the repulsive force at distances less than 2fm, but falls off rapidly at greater distances.
d. nuclei are stable only when the number of neutrons equals the number of protons.
e. nuclei are stable only when the number of protons exceeds the number of neutrons.
- 6D The isotope, tritium, (${}^3\text{H}$) has a half-life of 12.3 years. Assume we have 10 kg of the substance. What will be the initial decay rate, at $t = 0$ (in decays/s)?
a) 1.09×10^{14} b) 1.8×10^{-9} c) 5.6×10^8 d) 3.6×10^{18}
e) none of the above

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Elements of Quantum Physics

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7E In Compton scattering from stationary electrons the largest change in wavelength occurs when the photon is scattered through: the angle of
a) 0deg b) 45deg c) 90deg d) 180deg e) 270deg

8E Light of wavelength 400nm is incident on a certain metal. The stopping potential for the emitted electrons is measured to be 1.2V. What is the work function of this metal?
a) 4.3eV b) 3.1 eV c) 1.9eV d) 1.2eV e) 0.95 eV

9D The X ray intensity distribution function for X ray lamp is given on the figure.

It is evident that electrons have been accelerated to maximum velocity of v_{\max} . Their corresponding deBroglie's wavelength is given by λ_{dB}

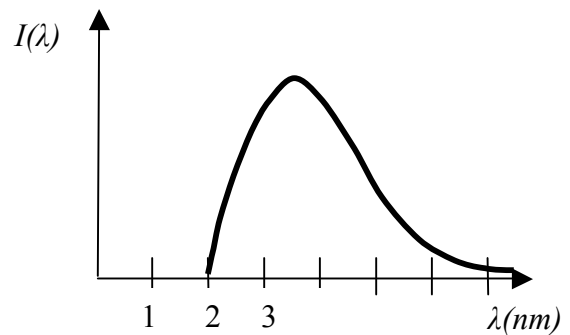
a) $v = 29.6 \times 10^3 \text{ km/s}$ $\lambda_{dB} = 0.049 \text{ nm}$

b) $v = 14.8 \times 10^3 \text{ km/s}$ $\lambda_{dB} = 2.0 \text{ nm}$

c) $v = 7.4 \times 10^3 \text{ km/s}$ $\lambda_{dB} = 2.0 \text{ nm}$

d) $v = 14.8 \times 10^3 \text{ km/s}$ $\lambda_{dB} = 0.049 \text{ nm}$

e) there is not enough information to answer question



10D The space station orbiting distant star ($r_{\text{star}} = 1 \text{ mln km}$, $R_{\text{orbit}} = 200 \text{ mln km}$) uses a hemispherical antenna of 40m diameter to power all of its operations. The opto-electrical module converts ALL of the EM energy received by the antenna into the electrical power with 20% efficiency. Find the wavelength for which the unknown star has the maximum in blackbody radiation profile. The station consumes 20kW of power.
a. 750nm b 890nm c. 1060nm d. 1330nm e. None of these answers

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OSCILLATIONS AND WAVE MECHANICS

11E Which of the following **describes** the simple harmonic oscillator (**SHO**) motion?

a) $\frac{d^2x}{dt^2} = -\frac{L}{g}x$ b) $\frac{d^2x}{dt^2} = \omega^2 x$ c) $\frac{d^2\theta}{dt^2} = -\frac{mgd}{I}\theta$ d) $\frac{d^2x}{dt^2} = \frac{k}{m}x$

e) none of the above are proper simple harmonic oscillator equations.

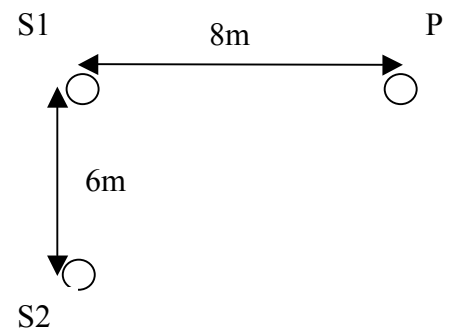
12E The equation describing horizontal motion of the mass m attached to a spring is given by:

$x = 2\pi \cos\left(\sqrt{\frac{3}{2}}t + \pi\right)$ where x is in meters and t in seconds. Find the magnitude of horizontal

acceleration of this body at time $t_1 = \sqrt{\frac{2}{3}}\pi$ seconds

a) 0 b) $-3\pi \text{ m/s}^2$ c) $2\pi \text{ m/s}^2$ d) $3\pi \text{ m/s}^2$ e) none of the above

13M Two speakers (S1 and S2) are separated by 6m and emit sound waves in phase. Point P is 8m away from the S1. What is the minimum frequency at which the intensity at point P is maximum? (speed of sound = 340m/s)



a) 340Hz b) 85Hz c) 170Hz d) 255Hz
e) none of the above

14M The explosion of a vertically launched firecracker in the air at a height of 40 m produces a 100-dB sound level at the ground below. What is the intensity level of the resulting sound heard by a reveler on the ground 50 m horizontally away from the point where the fire-cracker was launched.

a) 96dB b) 94dB c) 0.0039 W/m^2 d) 0.0025 W/m^2 e) none of the above

15D The siren of a police car moving at 40m/s has a natural frequency of 600Hz. A truck ahead of the car is moving at 20m/s in the same direction toward the wall. Trucker hears sound from the police car and sound reflected of the wall. What is the magnitude of the frequency difference between the sound received directly and the one reflected off the wall, heard by a trucker? (take V_{sound} to be 340m/s)

a) 60Hz b) 20Hz c) 40Hz d) 80Hz e) none of the above

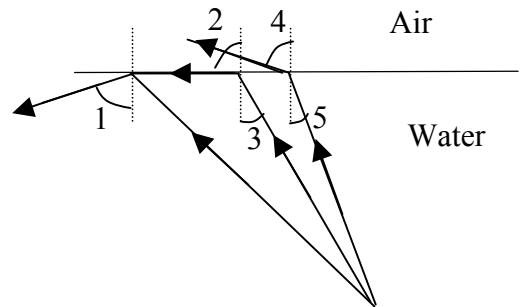
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OPTICS

16E Light from the underwater source falls on water-air interface. The critical angle is

- a) 1 b) 2 c) 3 d) 4 e) 5



17E A clown 2 m tall looks at himself in a full-length mirror (floor-to-ceiling). Where in the mirror must he look to see his feet? (For simplicity assume that the eyes of the human are at the top of the head)

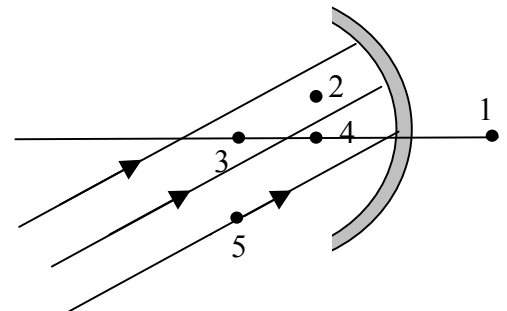
- a) 1 m from the floor b) 50 cm from the floor
c) at the bottom of the mirror d) 1.5 m from the floor
e) the answer depends on the distance between the clown and the mirror.

18E Which of following is not a phenomenon leading to production of polarized light from unpolarized light?

- a) absorption b) reflection c) birefringence d) scattering e) interference

19E Point 3 is the centre of curvature of the concave spherical mirror. The parallel rays incident on the surface of this mirror will most likely converge to a point at

- a) 1 b) 2 c) 3 d) 4 e) 5



20 M Two converging lenses of focal lengths 20cm and 30 cm are separated by 40cm. An object is located 15 cm in front of the 20cm lens. Where is the final image with respect to the second (30cm) lens?

- a) at -12cm b) at 12cm c) -43cm d) 43cm
e) none of these answers is correct

21M Two parallel glass plates of index of refraction n are separated by air film of thickness d . Light wavelength λ in air, normally incident on the plates intensified on reflection when for some integer m

- a) $2d = m\lambda$ b) $2d = m\lambda/n$ c) $2d = mn\lambda$ d) $2d = (m+1/2)\lambda$ e) $2d = m\lambda/2$

22D White light from air is incident normally on a film ($n=1.3$) of thickness 100nm deposited on glass ($n=1.5$). What is the phase difference between the rays reflected from the top and the bottom surfaces of the film for the 548 nm radiation?

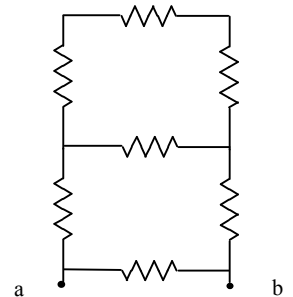
- a) 2.78rad b) 2.98rad c) 3.44rad d) 1.72rad e) none of the above

23D Light of a wavelength 480nm illuminates two slits separated by 0.12 mm. At what angle would one find the phase difference between the waves from two slits to be 2 radians

- a) 0.04° b) 0.04 rad c) 0.02 rad d) 0.07° e) none of these results

24E The current through a resistor is equal 1A. The potential drop on this resistor is 10 V. What is the value of the resistance?
a) 5Ω b) 10Ω c) 15Ω d) 20Ω e) none of the above

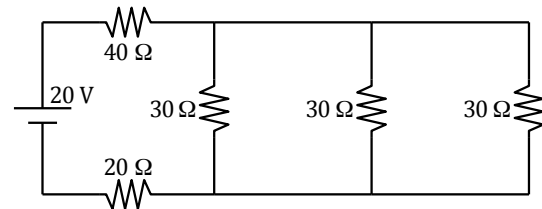
25E All resistors in this circuit are 10 ohm. Find the equivalent resistance between a and b
a) 5 b) 7.33 c) 10 d) 12.33 e) none of the above



26 E Two charges of 15 pC and -40 pC are inside a cube with sides that are of 0.40-m length. Determine the net electric flux (in $\text{N} \cdot \text{m}^2/\text{C}$) through the surface of the cube.
a) +2.8 b) -1.1 c) +1.1 d) -2.8 e) -0.47

27M At what rate (in W) is thermal energy being generated in the 20Ω resistor?

- a) 6.5
- b) 1.6
- c) 15
- d) 26
- e) 5.7

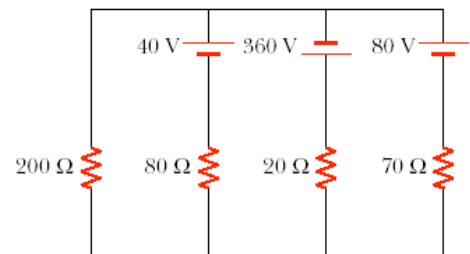


28M Find the Electric flux through the disk of radius $r=10\text{cm}$, at distance 3m from the point charge $Q=+1\text{C}$
a) $89.9 \times 10^6 \text{ N m}^2/\text{C}$ b) $76.5 \times 10^6 \text{ N m}^2/\text{C}$ c) $63 \times 10^6 \text{ N m}^2/\text{C}$ d) $31.4 \times 10^6 \text{ N m}^2/\text{C}$
e) none of the above

29M Find the electric Field E at Point (1,1,1) when the electric potential is given by the function $V(x,y,z) = xz+xy+yz + x^2+y^2 -3z^2$
a) $E(1,1,1) = (0,0,0)$ b) $E(1,1,1) = (3,7,1)$ c) $E(1,1,1) = (-4,-4,4)$ d) $E(1,1,1) = (4,4,-4)$
e) None of the above

30D In the circuit below, determine the magnitude of voltage across the $200\text{-}\Omega$ resistor.

- a. 10 V
- b. 50.0 V
- c. 100 V
- d. 200 V
- e. none of the above



- 31 D As thin spherical metal shell of radius $R=1\text{m}$ is charged to density of $+1\text{C}/\text{m}^2$
A small disk of the radius $r=5\text{cm}$ (and the charge that was on it) is then removed from the sphere by means of laser ablation. This process leaves the rest of the sphere unperturbed with its charge density intact. What is the magnitude of the electric field (in N/C) at the center of the sphere?
a) 70.5×10^6 b) 70.6×10^6 c) 90.5×10^6 d) 90.7×10^6 e) none of the above

Special Topics:

- 32 Which of the following is true about the NMR (Nuclear Magnetic Resonance) and PET (Positron Electron Tomography)
- a) Both PET and NMR are quite safe as they use small amounts of nuclear radiation for imaging
 - b) NMR is based on detecting absorption of nuclear radiation resonant with the energy structure of studied sample, while PET detects positrons and electrons produced by the radioactive sample
 - c) both methods involve high levels of X ray and γ radiation exposures and thus require expert radiologists to administer them safely
 - d) NMR is based on detecting a small shift in atomic energy caused by the magnetic field, while PET detects counter-propagating X rays originating from matter-antimatter annihilation.
 - e) none of the above statements is true
- 33 A far-sighted student has a near point of 1.0 m. Calculate the focal length (in cm) of the glasses needed so the near point will be normal (25 cm).
- a) 72 b) 25 c) 33 d) 100 e) -33

$$v_x = \frac{dx}{dt} \quad \vec{v} = \frac{d\vec{r}}{dt} \quad a_x = \frac{dv_x}{dt} \quad \vec{a} = \frac{d\vec{v}}{dt} \quad \vec{r}_f = \vec{r}_o + \vec{v}_o t + \frac{1}{2} \vec{a} t^2$$

$$a_t = \frac{dv}{dt} \quad a_c = \frac{v^2}{r} \quad \vec{F} = m\vec{a} \quad \vec{F}_o = -b\vec{v} \quad f = \mu N \quad R = \frac{1}{2} D\rho A v^2$$

$$F_B = \rho_l V \cdot g$$

$$\vec{F} = -k\vec{x} \quad W = \int \vec{F} \cdot d\vec{s} \quad K = \frac{mv^2}{2} \quad U_g = mgh \quad U_e = \frac{1}{2} kx^2 \quad \vec{P} = m\vec{v}$$

$$\vec{F} = \frac{d\vec{p}}{dt} \quad \vec{r}_{CM} = \frac{\sum m_i \vec{r}_i}{M} \quad r_{CM} = \frac{\int r dm}{M}$$

$$V = \frac{4}{3} \pi r^3 \quad A = 4\pi r^2 \quad A = \pi r^2 \quad C = 2\pi r$$

OSCILLATIONS AND WAVE MECHANICS

Angular frequencies of various oscillating systems

$\omega^2 = \frac{k}{m}$ mass m on the spring k

$\omega^2 = \frac{g}{L}$ simple pendulum

$$v = \sqrt{\frac{F}{\mu}} \quad v = \sqrt{\frac{S}{\rho}} \quad v = \sqrt{\frac{B + \frac{S}{3}}{\rho}}$$

$\omega^2 = \frac{mgd}{I}$ physical pendulum

$v_{sound} = 340 \frac{m}{s}$

$\omega^2 = \frac{K}{I}$ torsional pendulum

$$P = \frac{1}{2} \mu \omega^2 A^2 v \quad f' = \left[\frac{v \pm v_o}{v \pm v_s} \right] f_o \quad \beta = 10 \log \left[\frac{I}{I_o} \right] \quad I_o = 10^{-12} \frac{W}{m^2} \quad I = \left[\frac{P}{A} \right]$$

$v = f\lambda \quad \frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2} \frac{\partial^2 y}{\partial t^2}$

TABLE ELASTIC MODULI (x10⁹ N/m²)

	Y	S	B
Cast iron	100	40	90
Steel	200	80	140
Aluminum	70	25	70
Concrete	20		
Pine	7.6		
Water			2.1
Mercury			2.6

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SUMMARY OF ELECTRICITY

Coulomb's Law: $\vec{F} = \frac{k_e q_1 q_2}{r^2} \hat{r}$ $\vec{F} = \iint \frac{k_e dq_1 dq_2}{r^2} \hat{r}$

Electric Field $\vec{E} = \frac{k_e q}{r^2} \hat{r}$ $\vec{E} = \int \frac{k_e dq}{r^2} \hat{r}$ $\vec{F} = q\vec{E}$

Flux

$\Phi = \int \vec{E} \cdot d\vec{A}$

Gauss Law

$\Phi_{tot} = \oint \vec{E} \cdot d\vec{A} = \frac{q}{\epsilon_0}$

Electric Potential Energy U

$U = -q \int \vec{E} \cdot d\vec{r} = -qV$

Electric Potential V:

$V = -\int \vec{E} \cdot d\vec{r}$

$\vec{E} = -\text{grad } V$ $\vec{E} = E_x \hat{i} + E_y \hat{j} + E_z \hat{k}$ $E_x = -\frac{\partial V}{\partial x}; E_y = -\frac{\partial V}{\partial y}; E_z = -\frac{\partial V}{\partial z}$

Capacitance C

$C = \frac{q}{V}$ $C_{par} = \sum C_i$ $\frac{1}{C_{ser}} = \sum \frac{1}{C_i}$

Various Capacitor's Capacitances

Spherical: $C = 4\pi\epsilon_0 \frac{ab}{b-a}$ Cylindrical: $C = 2\pi\epsilon_0 \frac{l}{\ln(b/a)}$ Parallel plate: $C = \frac{\epsilon_0 A}{d}$

Isolated sphere: $C = 4\pi\epsilon_0 R$ Capacitor with dielectric:

$C_{diel} = k' C_{air}$

Current: $I = \frac{dQ}{dt}$ Resistance: $R = \rho \frac{L}{A}$ Ohm's Law:

$V = RI$

$R_{ser} = \sum R_i$ $\frac{1}{R_{par}} = \sum \frac{1}{R_i}$

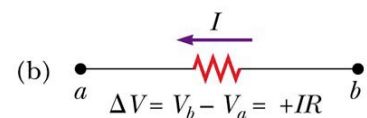
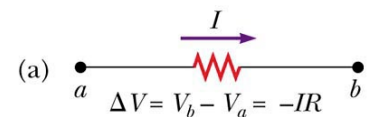
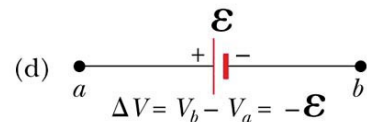
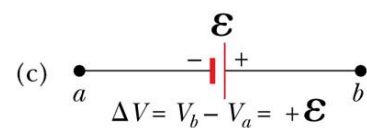
Power dissipated on resistor $P = VI = RI^2 = \frac{V^2}{R}$

RC circuits: charging the capacitor: $Q(t) = Q(1 - e^{-\frac{t}{RC}})$

RC circuits: discharging the capacitor: $Q(t) = Qe^{-\frac{t}{RC}}$

Kirchhoff's Rules Junction: $\sum I_{in} = \sum I_{out}$ Loop: $\sum V + \sum \mathcal{E} = 0$

Suggested sign convention for circuit analysis:



SUMMARY OF E-FIELD AND V FOR MOST IMPORTANT CHARGE DISTRIBUTIONS

Charge distribution	Distance	E field	V potential
Point charge	r	$k_e \frac{q}{r^2}$	$k_e \frac{q}{r}$
Many point charges	r_i $1 < i < N$	$\sum k_e \frac{q_i}{r_i^2}$	$\sum k_e \frac{q_i}{r_i}$
Insulating Charged Sphere	$r \geq R$	$k_e \frac{q}{r^2}$	$k_e \frac{q}{r}$
	$r < R$	$k_e \frac{q}{R^3} r$	$\frac{k_e q}{2R} (3 - \frac{r^2}{R^2}); V(r_0) = V(R)$
Conducting Charged Sphere	$r \geq R$	$k_e \frac{q}{r^2}$	$k_e \frac{q}{r}$
	$r < R$	0	$k_e \frac{q}{R}$
Charged Infinite thin line of charge	r	$2k_e \frac{\lambda}{r}$	$2\lambda k_e \ln \frac{r_0}{r}; V(r_0) = 0$
Infinite Charged insulating Cylinder	$r \geq R$	$2k_e \frac{\lambda}{r}$	$2\lambda k_e \ln \frac{R}{r}; V(R) = 0$
	$r < R$	$2\pi k_e \rho r = \frac{2k_e \lambda}{R^2} r$	$\pi k_e \rho (R^2 - r^2) = k_e \frac{\lambda}{R^2} (R^2 - r^2); V(R) = 0$
Infinite Charged Conducting Cylinder	$r \geq R$	$2k_e \frac{\lambda}{r}$	$2\lambda k_e \ln \frac{R}{r}; V(R) = 0$
	$r < R$	0	0
Infinite plane	y	$\frac{\sigma}{2\epsilon_0} = 2\pi k_e \sigma$	Ey

Finite continuous charge distributions:

Charge Distribution	Distance	E field	V potential
Finite Charged rod	y	$2k_e\lambda l \left(\frac{1}{y\sqrt{l^2 + y^2}} \right)$	$2k_e\lambda \ln \left(\frac{\sqrt{l^2 + y^2} + l}{y} \right)$
	x	$\frac{k_e q}{x(l+x)}$	$k_e\lambda \ln \left(\frac{x+l}{x} \right)$
Charged Ring	y	$\frac{k_e q y}{(\sqrt{R^2 + y^2})^3}$	$k_e \frac{q}{\sqrt{R^2 + y^2}}$
Charged Disk	y	$2\pi k_e \sigma_e \left(1 - \frac{y}{\sqrt{R^2 + y^2}} \right)$	$2\pi k_e \sigma (\sqrt{R^2 + y^2} - y)$

OPTICS

General Interference: $\frac{\delta}{\lambda} = \frac{\varphi}{2\pi}$

Double slit: $\delta = d \sin \theta = m\lambda$ (max) $\delta = d \sin \theta = (m + 1/2)\lambda$ (min)

Single slit: $a \sin \theta = m\lambda$ (min) Rayleigh criterion: $\theta_c = \frac{1.22\lambda}{a}$

$$I = I_{\max} \cos^2 \left(\frac{\pi d \sin \theta}{\lambda} \right) \approx I_{\max} \cos^2 \left(\frac{\pi d}{\lambda L} y \right) \quad I = I_{\max} \cos^2 \left(\frac{\pi d \sin \theta}{\lambda} \right) \left[\frac{\sin(\pi a \sin \theta / \lambda)}{\pi a \sin \theta / \lambda} \right]^2$$

$$R \equiv \frac{\lambda}{\lambda_2 - \lambda_1} = \frac{\lambda}{\Delta\lambda} \quad R = Nm$$

Polarization: $I = I_{\max} \cos^2 \theta$ $\tan \theta_B = \frac{n_2}{n_1}$

$n_1 \sin \theta_1 = n_2 \sin \theta_2$ $v(n) = \frac{c}{n}$ $v = f\lambda$

$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$ $\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1} \right) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$

Table 36.1

Sign Conventions for Mirrors		
Quantity	Positive When	Negative When
Object location (p)	Object is in front of mirror (real object)	Object is in back of mirror (virtual object)
Image location (q)	Image is in front of mirror (real image)	Image is in back of mirror (virtual image)
Image height (h')	Image is upright	Image is inverted
Focal length (f) and radius (R)	Mirror is concave	Mirror is convex
Magnification (M)	Image is upright	Image is inverted

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Table 36.2

Sign Conventions for Refracting Surfaces		
Quantity	Positive When	Negative When
Object location (p)	Object is in front of surface (real object)	Object is in back of surface (virtual object)
Image location (q)	Image is in back of surface (real image)	Image is in front of surface (virtual image)
Image height (h')	Image is upright	Image is inverted
Radius (R)	Center of curvature is in back of surface	Center of curvature is in front of surface

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Table 36.3

Sign Conventions for Thin Lenses		
Quantity	Positive When	Negative When
Object location (p)	Object is in front of lens (real object)	Object is in back of lens (virtual object)
Image location (q)	Image is in back of lens (real image)	Image is in front of lens (virtual image)
Image height (h')	Image is upright	Image is inverted
R_1 and R_2	Center of curvature is in back of lens	Center of curvature is in front of lens
Focal length (f)	Converging lens	Diverging lens

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MODERN PHYSICS AND RELATIVISTIC PHYSICS

Blackbody radiation:
$$u(\lambda)d\lambda = \frac{8\pi hc \lambda}{e^{\frac{hc}{\lambda kT}} - 1} d\lambda$$

$$\lambda_{\max} T = 2.898 \times 10^{-3} \text{ m.K} \quad P = \sigma A e T^4 \quad \sigma = 5.67 \times 10^{-8} \frac{W}{m^2 \cdot K^4}$$

$$E = hf \quad K_{\max} = hf - \Phi_o \quad \lambda = \frac{h}{p}$$

$$\Delta\lambda = \lambda' - \lambda_0 = \frac{h}{m_e c} (1 - \cos\theta)$$

Kinetic energy of charge q accelerated in the potential difference V : $K=qV$

Kinetic energy of particles moving with speed $v < 0.1c$: $K = \frac{1}{2} mv^2$

Kinetic energy of particles moving with speed $v > 0.1c$: $K = E - m_o c^2 = (\gamma - 1)m_o c^2$

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}} \quad \text{and} \quad E^2 = (pc)^2 + (m_o c^2)^2$$

Nuclear Physics:
$$R = 1.2 \text{ fm}(A)^{1/3} \quad N = N_o e^{\lambda t}$$

Mathematical Constants

Symbol	Value
π	3.14159...
e	2.71828...

Physical Constants

Useful Data

M_e	Mass of the earth	5.98×10^{24} kg	
R_e	Radius of the earth	6.37×10^6 m	
g	Free-fall acceleration on earth	9.80 m/s ²	
G	Gravitational constant	6.67×10^{-11} N m ² /kg ²	
k_B	Boltzmann's constant	1.38×10^{-23} J/K	
R	Gas constant	8.31 J/mol K	
N_A	Avogadro's number	6.02×10^{23} particles/mol	
T_0	Absolute zero	-273°C	
σ	Stefan-Boltzmann constant	5.67×10^{-8} W/m ² K ⁴	
p_{atm}	Standard atmosphere	101,300 Pa	
v_{sound}	Speed of sound in air at 20°C	343 m/s	
m_p	Mass of the proton (and the neutron)	1.67×10^{-27} kg	
m_e	Mass of the electron	9.11×10^{-31} kg	
K	Coulomb's law constant ($1/4\pi\epsilon_0$)	8.99×10^9 N m ² /C ²	
ϵ_0	Permittivity constant	8.85×10^{-12} C ² /N m ²	
μ_0	Permeability constant	1.26×10^{-6} Tm/A	
e	Fundamental unit of charge	1.60×10^{-19} C	
c	Speed of light in vacuum	3.00×10^8 m/s	
h	Planck's constant	6.63×10^{-34} J s	4.14×10^{-15} eV s
\hbar	Planck's constant	1.05×10^{-34} J s	6.58×10^{-16} eV s
a_B	Bohr radius	5.29×10^{-11} m	

Common Prefixes

Prefix	Meaning
femto-	10^{-15}
pico-	10^{-12}
nano-	10^{-9}
micro-	10^{-6}
milli-	10^{-3}
centi-	10^{-2}
kilo-	10^3
mega-	10^6
giga-	10^9
terra-	10^{12}

Conversion Factors

Length

1 in = 2.54 cm
1 mi = 1.609 km
1 m = 39.37 in
1 km = 0.621 mi

Velocity

1 mph = 0.447 m/s
1 m/s = 2.24 mph = 3.28 ft/s

Mass and energy

1 u = 1.661×10^{-27} kg
1 cal = 4.19 J
1 eV = 1.60×10^{-19} J

Time

1 day = 86,400 s
1 year = 3.16×10^7 s

Pressure

1 atm = 101.3 kPa = 760 mm of Hg
1 atm = 14.7 lb/in ²

Rotation

1 rad = $180^\circ/\pi = 57.3^\circ$
1 rev = $360^\circ = 2\pi$ rad
1 rev/s = 60 rpm