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Principles of Physics
PHY1322

Department of Physics

Instructor: Dr. Andrzej Czajkowski
Final Exam
April 11, 2011

Closed book exam
Duration: 3 hrs
<u>Return only the scantron sheets</u>

TOTAL OF 13 PAGES

1. Three capacitors are connected in parallel. Their capacitances are 16nF, 24nF, and 48nF. What is their total capacitance in nF?
a) 8 b) 36 c) 54 d) 62 e) 88

2. Two charges +Q and +4Q are separated by a distance r. At what distance from the greater charge, would a third test charge experience no net electrical force? ? /It has to be placed between the two charges/
a) $\frac{3}{2}r$ b) $\frac{r}{4}$ c) $\frac{r}{2}$ d) $\frac{2}{3}r$ e) impossible to answer

3. The total electric flux through a closed cylindrical (length $= 1.2$ m, diameter $= 0.20$ m) surface is equal to $-5.0\ \mathrm{Nm^2/C}$. Determine the net charge within the cylinder in pC. ($\varepsilon_o = 8.85 \times 10^{-12}\ \mathrm{C^2/Nm^2}$)
a) – 71 b) – 62 c) – 53 d) – 44 e) –16

4.The amplitude of a system moving with simple harmonic motion is doubled. The total energy will then be
a) 4 times larger b) 3 times larger c) 2 times larger d) the same as it was
e) half as much

5. A piano string of density 0.0050 kg/m is under a tension of 1350 N. Find the velocity with which a wave travels on the string.
a) 260 m/s b) 520 m/s c) 1040 m/s d) 2080 m/s e) 4160 m/s

6. An object 50-cm high is placed 1 m in front of a converging lens whose focal length is 1.5 m. Determine the image height (in cm).
a) 77 b) 150 c) 52 d) 17 e) 83

7. Sunlight reflected from a smooth ice surface is completely polarized. Determine the angle of incidence. ($n_{\text{ice}} = 1.31$.)
a. 52.6° b. 25.6° c. 65.2° d. 56.2° e. 49.8°

8. Monochromatic light (λ = 500 nm) is incident on a soap bubble (n = 1.40). How thick is the bubble (in nm) if destructive interference occurs in the transmitted light?
a. 102 b. 179 c. 54 d. 1 e. 89

9. Electron is accelerated in the uniform electric field between the potential of 100V and 20100V. What is the resulting change of the electron's kinetic energy ?
a) 20.1eV b) 21J c) 20keV d) 20.1keV e) none of the above

10. The inhabitants of a planet in another galaxy have their eyes at the exact center of their 4.0-m long bodies. How long must a plane mirror be for such a creature to be able to see all of its body in the mirror?
a) 1.0 m b) 2.0 m c) 2.5 m d) 4.0 m
e) it depends how far from the mirror is the alien.

11. Which of the groups of particles below are truly elementary according to Standard Model:
a) leptons, quarks, mesons
b) quarks, protons and gauge bosons
c) leptons, quarks and gauge bosons
d) leptons, hadrons and bosons
e) all of the particles listed in above choices are truly elementary according to Standard Model

12. Which of the following will make the true statement(s):

The Relic Radiation also known as Background Radiation

a) has a profile of black body radiation with maximum intensity at 2.7K

b) exhibits small temperature variations indicative of the mass density fluctuations in the early universe

c) exhibits small temperature variation indicative of the Inflation process in the early universe

d) a and b only

e) a and c only

13. Which stage(s) of stellar evolution **will not** be a part of our Sun future?

a) main sequence star,

b) white dwarf,

c) neutron star

d) red giant

e) all of the stages above will be part of the Sun's future.

14. Which of the following effects/processes play(s) important role in the operation of typical laser?

a) stimulated emission

b) population inversion

c) photoelectric effect

d) a and b only

e) a and c only

15. Principle of operation of a music synthesizer is based on

a) resonance principle

b) Fourier theorem

c) logarithmic scale

d) interference

e) none of the above

16. An electron traveling with a velocity of $1.1\text{x}10^6$m/s has a de Broglie wavelength of approximately:

a) 0.66nm b) 0.78nm c).89nm d) 0.97nm e)1.2nm

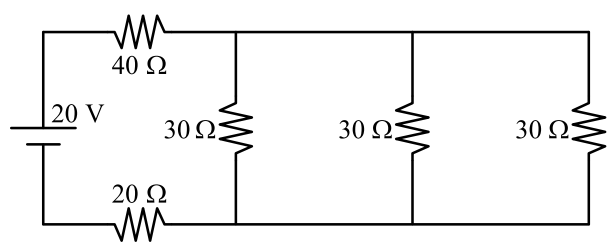
17. An electric heater is constructed by applying a potential difference of 110 V across a wire with a resistance of 5.0 Ω. What is the power rating of the heater?

a) 2.0 kW b) 2.4 kW c) 1.7 kW d) 1.5 kW e) 60 kW

18. A capacitor in a single-loop *RC* circuit is charged to 85% of its final potential difference in 2.4 s. What is the time constant for this circuit?

a) 1.5 s b) 1.3 s c) 1.7 s d) 1.9 s e) 2.9 s

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



a. 6.5

b. 1.6

c. 15

d. 26

e. 5.7

20 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

21 Parallel beam of light (wavelength= 514nm in the air, n=1) enters the medium of refractive index of 1.532. at angle of incidence of 60^o to the normal. What is the angle of refraction r and the wavelength of the light inside the new medium λ(n) ?

a) r = 0.7rad; λ(n)= 514 nm
b) r = 0.6rad; λ(n)= 336 nm
c) r = 0.6rad; λ(n)= 514nm
d) r= 0.7rad; λ(n)= 336nm
e) none of the above

22. The cutoff wavelength for photoelectric emission of a particular substance is 500 nm. What is the work function in eV?

a) 4.2 b) 4.0×10^{-19} c) 4.0×10^{-10} d) 2.5×10^{-19} e) 2.5

23. 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

24 A uniform rod of mass m and length L is freely pivoted at one end. What is the period of its oscillations. I_{CM} for uniform rod rotating about its centre of mass is $\frac{1}{12}mL^2$.

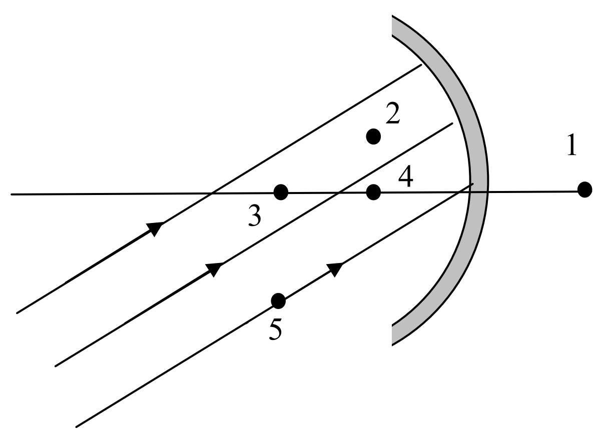
a) $\sqrt{\frac{3g}{2L}}$ b) $2\pi\sqrt{\frac{3L}{2g}}$ c) $2\pi\sqrt{\frac{2L}{3g}}$ d) $2\pi\sqrt{\frac{L}{g}}$ e) none of the above

25. Ideally, how close together in km could 2 objects on the moon's surface be if they can just be resolved by the human eye? D (Earth-moon) $= 385{,}000$ km , λ (visible) $= 5.00 \times 10^{-7}$ m , and d(pupil) $= 0.00700$ m . Assume eye fluid has an average $n = 1.33$.

a) 170 b). 335 c) 33.5
d) 25.2 e) 42.0

26 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

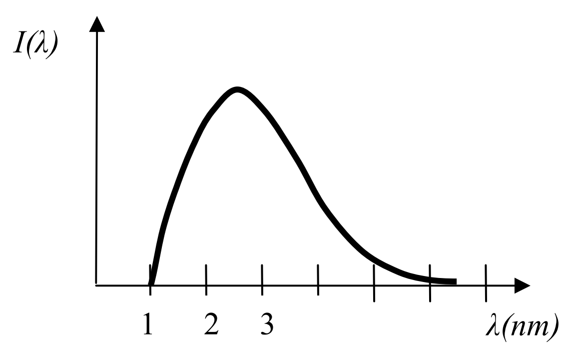


27. By what factor will an intensity change when the corresponding sound level increases by 6 dB?

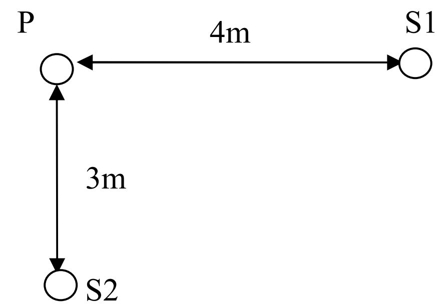
a) 3 b) 0.5 c) 2
d) 4 e) 0.3

28 .The X ray intensity distribution function for X ray lamp is given on the figure. Based on this profile one could say that the X-ray lamp was operating under the following potential difference:

a) 2960V
b) 980V
c) 1240V
d) not enough information to answer
e) none of the above



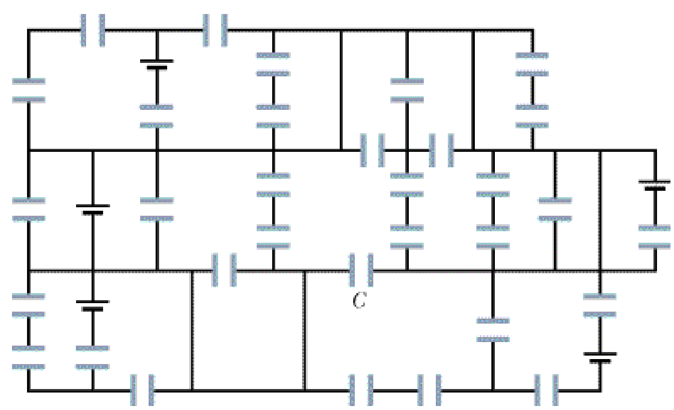
29. An observer stands 3 m from speaker A and 4 m from speaker B. Both speakers, oscillating in phase, produce 170 Hz waves. The speed of sound in air is 340 m/s. What is the phase difference (in radians) between the waves from A and B at the observer's location, point P?



a) 0 b) $\frac{\pi}{2}$ c) π d) 2π e) 4π

30. All are fully charged and capacitors have capacitance of 4mF and al batteries have emf 4V. What is the charge (in mC) on the capacitor C?
(Hint: I you find proper loop in this maze you can solve this in less than one minute of mental calculations)

a) 2.0
b) 4.0
c) 8.0
d) 16.0
e) None of the above



31 The first unmanned probe called "Albert Einstein's cousin" will reach the stellar system of the Alfa Centauri (estimated radius $5x10^4$km) in year 2145. The probe will enter stationary orbit of radius R=3.0 $x10^8$ km. In order to power itself the probe will convert all of the radiation energy received from the star by its hemispherical antenna (radius=10m). It is estimated that when oriented at a right angle with respect to the incoming radiation, the antenna will collect total power of $3x10^5$W. From this information find the λ_{max}, wavelength for which the Alfa Centauri emits most of its energy

a) 124 nm b) 104nm c) 147nm d) 78nm
e) information provided is insufficient to solve this problem, or none of these answers is true.

32. A metal of work function 5eV is illuminated with the light emitted by a black body. The cut off frequency of the metal corresponds to the frequency at which blackbody emission has maximum. Find the temperature of the black body.
a) 10.41K b) 104.0K c) 1166K d) 11 660K e) none of the above

33 Light of a wavelength 548nm illuminates two slits separated by 0.25 mm. At what angle would one find the phase difference between the waves from two slits to be 2 radians?
a) 0.04^o b) 0.04 rad c) 0.02 rad d)0.02^o e) none of these results

Rotational motion About a Fixed Axis

Angular speed $\omega = {d\theta}/{dt}$

Angular acceleration $\alpha = {dw}/{dt}$

Net torque $\sum \tau = I\alpha$

$$\text{If } \alpha = const. \begin{cases} \omega_f = \omega_i + \alpha_t \\ \theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2 \\ \omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i) \end{cases}$$

Work $W = \int_{\theta_i}^{\theta_f} \tau \quad d\theta$

Rotational kinetic energy $K_R = \frac{1}{2} I\omega^2$

Power $P = \tau\,\omega$

Angular momentum $L = I\omega$

Net torque $\sum \tau = {dL}/{dt}$

Circular Hoop $I_{CM} = MR^2$

Hollow cylinder $I_{CM} = \frac{1}{2} M(R_1^2 + R_2^2)$

where R_1: inner radius, R_2: outer radius

Solid cylinder or disc $I_{CM} = \frac{1}{2} MR^2$

Thin Rectangle $I_{CM} = \frac{1}{12} M(a^2 + b^2)$

Long thin road with rotational axis through center $I_{CM} = \frac{1}{12} ML^2$

Long thin road with rotational axis through edge $I_{CM} = \frac{1}{3} ML^2$

Solid sphere $I_{CM} = \frac{2}{5} MR^2$

Thin spherical shell $I_{CM} = \frac{2}{3} MR^2$

Mechanics

$$v_x = \frac{dx}{dt} \qquad \vec{v} = \frac{d\vec{r}}{dt}$$

$$a_x = \frac{dv_x}{dt} \qquad \vec{a} = \frac{d\vec{v}}{dt}$$

$$\vec{r}_f = \vec{r}_o + \vec{v}_o t + \frac{1}{2}\vec{a}\,t^2$$

$$a_t = \frac{dv}{dt} \qquad a_c = \frac{v^2}{r}$$

$$\vec{F} = m\vec{a} \qquad \vec{F}_o = -b\vec{v}$$

$$f = \mu N \qquad R = \frac{1}{2}D\rho A v^2$$

$$F_B = \rho_l V.g$$

$$\vec{F} = -k\vec{x}$$

$$W = \int \vec{F}.d\vec{s}$$

$$k = \frac{mv^2}{2}$$

$$U_g = mgh$$

$$U_e = \frac{1}{2}kx^2$$

$$\vec{P} = m\vec{v}$$

$$\vec{F} = \frac{d\vec{p}}{dt}$$

$$\vec{r}_{CM} = \frac{\sum m_i \vec{r}_i}{M} \qquad r_{CM} = \frac{\int r\,dm}{M}$$

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

$$A = \pi r^2 \qquad C = 2\pi r$$

SUMMARY OF ELECTRICITY

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

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

Flux

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

Gauss Law

$$\Phi_{tot} = \oint \vec{E}\cdot d\vec{A} = \frac{q}{\varepsilon_0}$$

Electric Potential Energy U

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

Electric Potential V:

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

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

Capacitance C

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

Various Capacitor's Capacitances

Spherical: $C = 4\pi\varepsilon_0 \dfrac{ab}{b-a}$ $\quad$ Cylindrical: $C = 2\pi\varepsilon_0 \dfrac{l}{\ln(b/a)}$ Parallel plate: $C = \dfrac{\varepsilon_0 A}{d}$

Isolated sphere: $C = 4\pi\varepsilon_0 R$ $\quad$ Capacitor with dielectric: $C_{diel} = \kappa\, C_{air}$

Current: $I = \dfrac{dQ}{dt}$ $\quad$ Resistance: $R = \rho\dfrac{L}{A}$ $\quad$ Ohm's Law: $V = RI$

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

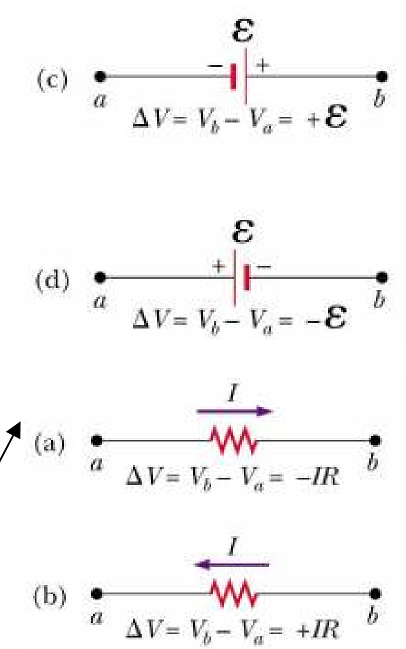
Power dissipated on resistor $P = VI = RI^2 = \dfrac{V^2}{R}$

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 $\quad$ Junction: $\Sigma I_{in} = \Sigma I_{out}$ $\quad$ Loop: $\Sigma V + \Sigma \varepsilon = 0$

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	$k_e \frac{q}{r^2}\hat{r}$	$k_e \frac{q}{r}$
Many point charges	ri 1<i<N	$\sum k_e \frac{q}{r_i^2}\hat{r}_i$	$\sum k_e \frac{q}{r_i}$
Insulating Charged Sphere	r≥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≥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≥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≥R	$2k_e \frac{\lambda}{r}$	$2\lambda k_e \ln\frac{R}{r};V(R)=0$
	r<R	0	0
Infinite plane	y	$\frac{\sigma}{2\varepsilon_0} = 2\sigma\pi k_e$	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	$\frac{k_e q y}{\left(\sqrt{R^2+y^2}\right)^3}$	$k_e\frac{q}{\sqrt{R^2+y^2}}$
Charged Disk	y	$2\pi k\sigma_e\left(1-\frac{y}{\sqrt{R^2+y^2}}\right)$	$2\pi k_e\sigma\left(\sqrt{R^2+y^2}-y\right)$

OPTICS

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

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

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

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

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

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

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

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

SIGN CONVENTIONS

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

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

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

MODERN PHYSICS AND RELATIVISTIC PHYSICS

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

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

$E = hf$ $\qquad K_{\max} = hf - \Phi_o$ $\qquad \lambda = \dfrac{h}{p}$

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

Kinetic energy of charge q accelerated in the potential difference U:K=qU

Kinetic energy of particles moving with speed v < 0.1c: K = ½ mv^2

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

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

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

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

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

$v_{sound} = 340\, {}^{m}\!/\!{}_{s}$ $\quad v = \sqrt{\frac{F}{\mu}}$ $\quad v = \sqrt{\frac{S}{\rho}}$ $\quad v = \sqrt{\frac{B + \frac{S}{3}}{\rho}}$

$$P = \frac{1}{2}\mu\omega^2 A^2 v$$

$$f' = \left[\frac{v \pm v_o}{v \pm v_s}\right] f$$

$\beta = 10\log\left[\frac{I}{I_o}\right]$ $\quad I_o = 10^{-12}\, {}^{W}\!/\!{}_{m^2}$ $\quad I = \left[\frac{P}{A}\right]$

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

TABLE ELASTIC MODULI (x10^9 N/m^2)

	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

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} T m/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 = $180°/\pi$ = 57.3°
1 rev = 360° = 2π rad
1 rev/s = 60 rpm