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Principles of Physics
PHY1322

Department of Physics

Instructor: Dr. Andrzej Czajkowski
Final Exam
April 21, 2015
Closed book exam
Duration: 3 hrs
Return only the scantron sheets

ELECTRICITY

1E. Three resistors are connected in parallel. Their resistances 16Ω, 24 Ω, and 48 Ω.
What is their equivalent resistance in Ω?
a) 8 b) 36 c) 54 d) 62 e) 88

2E. 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

3E. 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 Nm^2/C) through the whole surface of the cube.
a. +2.8 b. –1.1 c. +1.1 d. –2.8 e. –0.47

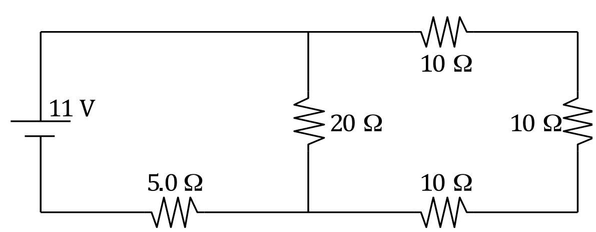
4E. Find the electric Field E at Point (1,1,1) when the electric potential is given by the function
$V(x,y,z) = 10 + yzx + x^2 + y^2 - 2z^2$
a) E(1,1,1) = (0,0,0) b) E(1,1,1) =(-3,-3,3) c) E(1,1,1) =(-4,-4,4)
d) E(1,1,1) =(4,4,-4) e) None of the above

5 M. A hemispherical surface (half of a spherical surface) of radius *R* is located in a uniform electric field of magnitude *E* that is parallel to the axis of the hemisphere. What is the magnitude of the electric flux through the hemisphere surface?

a. $\pi R^2 E$ **b.** $4\pi R^2 E/3$ **c.** $2\pi R^2 E/3$ **d.** $\pi R^2 E/2$ **e.** $\pi R^2 E/3$

6M. What is the magnitude (in V) of the potential difference across the 20 Ω resistor?

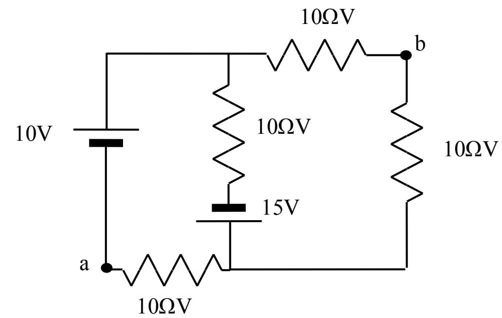
a) 3.2
b) 7.8
c) 11
d) 5.0
e) 8.6



7D As thin spherical metal shell of radius R=1m is charged to density of $+1C/m^2$
A small disk of the radius r=5cm (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

8D. Determine the potential difference $V_a - V_b$ shown in the circuit below.

a. –5.0 V
b. +5.0 V
c. –10 V
d. +10 V
e. 0 V



VIBRATIONS AND MECHANICAL WAVES

9E. 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 e) half as much

as before

10E. A piano string of density 0.0050 kg/m is under a tension of 1350 N. Find the velocity (in m/s) with which a wave travels on the string.

a) 260 b) 520 c) 1040 d) 2080 e) 4160

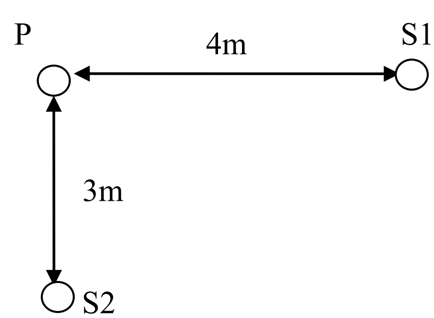
11E. Principle of operation of a music synthesizer is based on
a) resonance principle
b) Fourier theorem
c) logarithmic scale
d) interference
e) none of the above

12E. 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

13M. 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



OPTICS

14E 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

15E If a bi-convex lens was made out of very thin clear plastic filled with air, and was then placed underwater where *n* = 1.33 and where the lens would have an effective index of refraction *n* = 1, the lens would act in the same way

a. as a concave mirror in air.
b. as a bi-concave lens in air.
c. as a bi-convex lens in air.
d. as a flat refracting surface between water and air as seen from the water side.
e. as the glasses worn by a farsighted person.

16E. 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.

17E. Light reflected off a plate-glass window (*n* = 1.5) is found to be completely polarized at angle-of-incidence *q*. Find *q*.

a. 56.3° **b.** 5.7° **c.** 21.2° **d.** 18.6° **e.** 33.7°

18E 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

19M 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)= 400nm b) r = 0.6rad; λ(n)= 336 nm
c) r = 0.6rad; λ(n)= 514nm d) r= 0 rad; λ(n)= 787nm
e) none of the above

20E. 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 reflected light?

a. 102 b. 179 c. 54 d. 1 e. 89

21M Two parallel glass plates of index of refraction n are separated by oil film of thickness d and refractive index $n = n_{glass}$. Light has wavelength λ in the air, it is normally incident on the plates. What is the condition for the intensity increase in the reflection at some integer m.
a) 2d=m λ b) 2d=mnλ c) 2dn=m λ d) 2d=(m+ ½) λ e) 2dn=(m+ ½) λ

22M 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

ELEMENTARY PARTICLES AND ASTROPHYSICS

23E 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

24E Main Sequence Star
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 and shrinking
d) is a type of neutron star
e) none of the above

25E Relic radiation
A) is almost perfectly non-isotropic and its temperature is close to 3K
B) is almost perfectly isotropic and its temperature depends strongly on the direction of observation
c) is almost perfectly isotropic and its temperature is close to 3K
d) has not yet been confirmed experimentally
e) is a radiation emitted by large black holes

26M Which of the pairs of particles below consists of two different Majorana particles /Majorana particle is its own antiparticle. This is dual question – I am asking whether both particles in the pair are Majorana particles – and not if one of them is the another's antiparticle.

a) electron and proton
b photon and Z boson
c) W+ boson and W- boson
d) up quark and muonic neutrino
e) none of the above pairs are two different Majorana particles

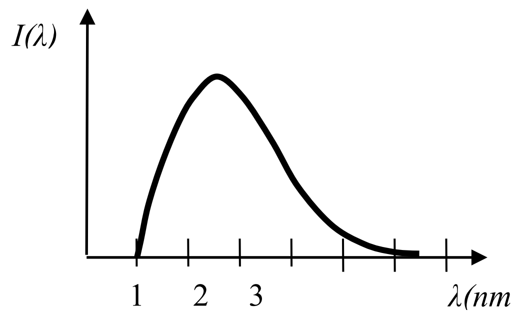
QUANTUM PHYSICS

27E 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

28E 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

29M. 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



30D. 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 certain blackbody emission has maximum. Find the temperature of the black body.
a) 10.4K b) 104K c) 1166K d) 11 660K e) none of the above

31D. The electron on the first Bohr's orbit has de Broglie's wavelength of

a) 0.66nm b) 0.33nm c).053nm d) 0.021nm e)none of the above

NUCLEAR PHYSICS:

32(E) Liquid drop model

a) predicts correctly the magic numbers
b) predicts correctly the values of magnetic moments of proton and neutron
c) explains correctly the mechanism for the light nuclei fusion
d) explains correctly what happens when heavy nucleus is bombarded by thermal neutrons
e) is an old model no longer useful – it has been replaced by the shell model

33 (M) 44 g of petrified wood was found in a petrified forest. A sample showed a ^{14}C activity of 100 decays/minute. How long has the tree been dead (in years)? (The half-life of carbon-14 is 5730 years and freshly cut wood contains 6.5×10^{10} atoms of ^{14}C per gram.)

a) 12 300
b) 15 600
c) 8 500
d) 4 700
e) 2 400

Rotational motion About a Fixed Axis

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

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

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

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

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

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

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

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

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

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

$$F_B = \rho_l V.g$$

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

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

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

$$U_g = mgh$$

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

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

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

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

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

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

<u>SUMMARY OF ELECTRICITY</u>

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

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

Electric Potential Energy U

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

Electric Potential V:

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

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

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

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

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

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

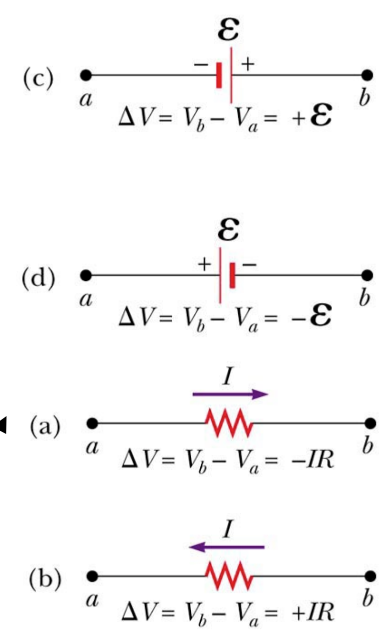
Power dissipated on resistor $P = VI = RI^2 = \frac{V^2}{R}$

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: $\sum V + \sum \varepsilon = 0$

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(r0)=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) $\delta = d\sin\theta = (m+\frac{1}{2})\lambda$ (min)

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

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

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

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

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

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

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

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 NULCEAR PHYSICS

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

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

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

Kinetic energy of charge q accelerated in the potential difference 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 $E^2 = (pc)^2 + (m_o c^2)^2$

$N = N(0) e^{-\lambda t}$ $\quad R({}^A_Z X) = 1.2\, fm \cdot \sqrt[3]{A}$

OSCILLATIONS AND WAVE MECHANICS

Angular frequencies of various oscillating systems

$\omega^2 = \dfrac{k}{m}$	mass m on the spring k
$\omega^2 = \dfrac{g}{L}$	simple pendulum
$\omega^2 = \dfrac{mgd}{I}$	physical pendulum
$\omega^2 = \dfrac{K}{I}$	torsional pendulum

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

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

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

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

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

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