Motion in a Circle

(1) length of arc $= r\theta$

(2) $1 \text{ rad} = 57.3^\circ$

(3) $\omega = \dfrac{\Delta\theta}{\Delta t} = \dfrac{2\pi}{T}$

(4) $\boxed{v = r\omega}$

(5) centripedal $\boxed{\text{acceleration} = \dfrac{v^2}{r} = r\omega^2}$

☆ (6) centripedal $\boxed{\text{force} = \dfrac{mv^2}{r} = mr\omega^2}$

(7) $\boxed{v^2 = gr}$

r: radius

θ: angle in rad.

ω: angular speed

t: time.

v: linear speed

Gravitational fields

☆ (8) $\boxed{F_{grav} = \dfrac{Gm_1m_2}{r^2}}$

(9) $\dfrac{Gm_1m_2}{r^2} = \dfrac{mv^2}{r} \Rightarrow v^2 = \dfrac{GM}{r}$

(10) $\dfrac{T^2}{r^3} = \dfrac{4\pi^2}{GM}$

(11) $g = \dfrac{GM}{r^2}$

$P.E_{Grav} = m\varphi = -\dfrac{GMm}{r}$

(12) $\phi = -\dfrac{GM}{r}$

Difference btwn 2 points:

☆ (13) $P.E_{grav} = \underset{\text{final}}{\dfrac{GMm}{r}} - \underset{\text{initial}}{\dfrac{GMm}{r}} = F\Delta r$

G: Gravitational constant

Escape velocity: $v = \sqrt{\dfrac{2GM}{R}}$

T: period.

M: mass of larger object

ϕ: gravitational potential

Ideal Gases

(14) $pV = k$

(15) $pV = nRT$

(16) $pV = NkT$

(17) $c^2 = c_x^2 + c_y^2 + c_z^2$

$\langle c_x^2 \rangle = \langle c_y^2 \rangle = \langle c_z^2 \rangle$

$\langle c_x^2 \rangle = \frac{1}{3}\langle c^2 \rangle$

(18) Kinetic theory equations:

$pV = \frac{1}{3}Nm\langle c^2 \rangle$

(19) $p = \frac{1}{3}\rho\langle c^2 \rangle$

p: pressure V: volume

R: molar gas constant

N: no. of molecules in a gas

k: Boltzmann constant

c: velocity

c_x: x-component of c

ρ = density

(20) Average E_k of a molecule:

$$\langle E_k \rangle = \frac{1}{2} m \langle c^2 \rangle = \frac{3}{2} kT$$

(21) Root-mean-square speed:

$$C_{rms} = \sqrt{3kT/m}$$

Temperature

(22) $\theta = \frac{100(P_\theta - P_i)}{(P_s - P_i)}$

(23) $\theta = K - 273.15$

P_i: thermometric property at ice-point.
P_s: thermometric property at steam-point.
P_θ: themometric property at unknown temp. θ

Thermal properties

(24) $\Delta Q = mc\Delta\theta$ Specific heat capacity

(25) $\Delta Q = mL$ Specific latent heat

(26) $\Delta U = q + W$

ΔU: internal energy
q: thermal energy
W: work done.

Oscillations

(27) $a = -\omega^2 x$

(28) $\omega = 2\pi f$

(29) $x = x_0 \sin \omega t$ $t=0, x=0$ given

$x = x_0 \cos \omega t$ $t=0, x=x_0$

(30) $v = x_0 \omega \cos \omega t$ $t=0, x=0$

$v = -x_0 \omega \sin \omega t$ $t=0, x=x_0$

(31) $v_0 = x_0 \omega$

(32) $v = \pm \omega \sqrt{x_0^2 - x^2}$

(33) $a = -x_0 \omega^2 \sin \omega t$ $t=0, x=0$

$a = -x_0 \omega^2 \cos \omega t$ $t=0, x=x_0$

ω: angular frequency.
x: displacement

(34) $F = kx$ Hooke's law.

(35) $T = 2\pi \sqrt{\frac{m}{k}} = 2\pi \sqrt{\frac{l}{g}}$

(36) $F_{restoring} = -m\omega^2 x$

(37) $E_k = \frac{1}{2} m\omega^2 (x_0^2 - x^2)$ $E_p = \frac{1}{2} m\omega^2 x^2$

(38) $E = \frac{1}{2} m\omega^2 x_0^2$

Communications (39) Signal-to-noise ratio or gain (dB) $= 10 \log \left(\frac{\text{signal power}_{out}}{\text{noise power}_{in}} \right)$ (W)

(40) $\frac{\text{Attenuation per unit length (dB km}^{-1})}{} = \frac{\text{attenuation (dB)}}{\text{length of cable (km)}} = \left(\frac{1}{L} \right) 10 \log \left(\frac{\text{signal power}}{\text{noise power}} \right)$

Electric fields (41) $F = \frac{Q_1 Q_2}{4\pi \varepsilon_0 r^2}$

ε_0: permittivity of free space.

(42) $E = \frac{Q}{4\pi \varepsilon_0 r^2}$

E: electric field strength

(43) $V = \frac{Q}{4\pi \varepsilon_0 r}$ given

V: potential.

Capacitance (44) $C = \frac{Q}{V}$ $Q = CV$

C: capacitance. (farad)

(45) $C = \frac{\varepsilon_0 A}{d}$

(46) Series: $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} \dots$

Parallel: $C = C_1 + C_2 \dots$

(47) $E_p = \frac{1}{2} QV = \frac{1}{2} CV^2 = \frac{Q^2}{2C}$

(48) Discharging: $Q = Q_0 e^{-t/CR}$

(49) Time constant = CR

Electronics (Amplifiers) (50) $V_{out} = G_0 (V^+ - V^-)$

V_{out}: output voltage

G_0: open-loop gain

G: feedback gain equals 1

(51) $\frac{V_{out}}{V_{in}} = \frac{G_0}{1 + G_0} = G$

(52) $\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$ (inverting amplifier)

$I_f = -I_{in}$

$\frac{V_{out}}{V_{in}}$ = Gain (53) $\frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_1}$ (non-inverting amplifier)

$I_{in} = I_{out}$

Magnetic Fields & Electromagnetic induction.

★ (54) $F_B = BIL \sin\theta$

★ (55) $F_B = Bqv \sin\theta$

(56) $\phi_B = BA \sin\theta$

(57) specific charge $= \frac{q}{m}$

★ (58) $E = Bv$

(59) Hall voltage, $V_H = \frac{BI}{ntq}$ given.

★ (60) $\Delta(N\Phi) = N\Delta\Phi$

(61) $E = \frac{-d(N\Phi)}{dt}$ Lenz law.

B: flux density (Tesla)
ϕ: flux (Weber)
A: area.

n: number density of conducting particles
E: electric field.
t: thickness of wire or conductor.
N: no. of turns
$\Delta(N\Phi)$: change in flux linkage.
E: emf.

A.C

(62) $I = I_0 \sin \omega t$
$V = V_0 \sin \omega t$

(63) $P = I_0^2 R \sin^2 \omega t$
$\langle P \rangle = \frac{1}{2} I_0^2 R = \frac{1}{2} \frac{V_0^2}{R}$

(64) $I_{rms} = \sqrt{\langle I^2 \rangle} = \frac{I_0}{\sqrt{2}}$

$V_{rms} = \sqrt{\langle V^2 \rangle} = \frac{V_0}{\sqrt{2}}$

P: Power.

Quantum Physics

★ (65) $E = hf$

(66) $\phi = hf_0$

★ (67) $hf = hf_0 + \frac{1}{2} m_e v_{max}^2$ (KE max) KE_{max} = stopping potential $= eV_0$

(68) $\lambda = \frac{h}{p}$ - Wave particle duality

★ (69) $\lambda = \frac{hc}{\Delta E}$; $\Delta E = hf$ - Energy levels.

★ (70) $\lambda_0 = \frac{hc}{eV}$

E: energy
h: Planck constant
ϕ: work function energy
f_0: threshold frequency
λ: de Broglie wavelength
p: momentum.
c: speed of light
λ_0: cut-off wavelength
e: charge of electron.

Attenuation of X-rays:

(71) $I = I_0 e^{-\mu x}$ given.

(72) $\ln 2 = \mu x_{1/2}$

↳ half-value thickness

Nuclear Physics:

(73) $E = mc^2$

(74) $1\ \text{MeV} = 1.60 \times 10^{-13}\ \text{J}$

(75) $\lambda = -N\left(\frac{dN}{dt}\right)$

$$\frac{dN}{dt} = A$$

$A = \lambda N$ $\quad\quad$ $N = n N_A$

(76) $N = N_0 e^{-\lambda t}$

$A = A_0 e^{-\lambda t}$

(77) Half life, $t_{1/2} = \frac{\ln 2}{\lambda}$ given

$$N = \frac{m}{M_r \times u}$$

I_0: incident intensity

I: transmitted intensity

x: thickness (cm)

μ: linear attenuation coefficient or linear absorption coefficient of the medium.

MeV: mega electronvolt.

λ: decay constant $= \frac{d}{dt}$

N: no. of nuclei

$\frac{dN}{dt}$: rate of decay.

A: activity of source (becquerels)

N_0: initial no. of undecayed nuclei