FORMULAE SHEET

1. Mechanics

1. Absolute error $(a_m) = \dfrac{a_1 + a_2 + a_3 + \ldots a_n}{n}$
2. Mean absolute error $(\Delta\overline{a}) = \dfrac{|\Delta a_1| + |\Delta a_2| + \ldots + |\Delta a_n|}{n}$
3. Relative error $= \dfrac{\text{Mean absolute error } (\Delta\overline{a})}{\text{Absolute error}(a_m)}$
4. Percentage error $= \dfrac{\Delta\overline{a}}{a_m} \times 100\%$
5. Error in addition or subtraction
   $$\Delta x = \pm (\Delta a + \Delta b)$$
6. Error in multiplication or division
   $$\frac{\Delta x}{x} = \pm \left(\frac{\Delta a}{a} + \frac{\Delta b}{b} \right)$$
7. Scalar product of orthogonal unit vectors
   $$\hat{\mathbf{i}} \cdot \hat{\mathbf{i}} = \hat{\mathbf{j}} \cdot \hat{\mathbf{j}} = \hat{\mathbf{k}} \cdot \hat{\mathbf{k}} = 1$$
   and $\hat{\mathbf{i}} \cdot \hat{\mathbf{j}} = \hat{\mathbf{j}} \cdot \hat{\mathbf{k}} = \hat{\mathbf{k}} \cdot \hat{\mathbf{i}} = 0$
8. Scalar product in cartesian coordinates
   $$\mathbf{A} \cdot \mathbf{B} = A_x B_x + A_y B_y + A_z B_z$$
9. Vector product of orthogonal unit vectors
   $$\hat{\mathbf{i}} \times \hat{\mathbf{i}} = \hat{\mathbf{j}} \times \hat{\mathbf{j}} = \hat{\mathbf{k}} \times \hat{\mathbf{k}} = 0$$
   and $\hat{\mathbf{i}} \times \hat{\mathbf{j}} = \hat{\mathbf{k}}, \hat{\mathbf{j}} \times \hat{\mathbf{k}} = \hat{\mathbf{i}}, \hat{\mathbf{k}} \times \hat{\mathbf{i}} = \hat{\mathbf{j}}$
10. Vector product in cartesian coordinates
    $$\mathbf{A} \times \mathbf{B} = (A_y B_z - A_z B_y)\,\hat{\mathbf{i}} - (A_x B_z - B_x A_z)\,\hat{\mathbf{j}} + (A_x B_y - A_y B_x)\,\hat{\mathbf{k}}$$
11. Area = Length × Breadth
12. Volume = Length × Breadth × Height

13. Density $= \dfrac{\text{Mass}}{\text{Volume}}$

14. Speed $= \dfrac{\text{Distance}}{\text{Time}}$

15. Instantaneous speed $= \lim\limits_{\Delta t \to 0} \dfrac{\Delta s}{\Delta t}$

16. Velocity $= \dfrac{\text{Displacement}}{\text{Time taken}}$

17. Acceleration $= \dfrac{\text{Change in velocity } (\Delta v)}{\text{Time interval } (\Delta t)}$

18. Equations of Motion

    (i) $v = u + at$

    (ii) $s = ut + \dfrac{1}{2} at^2$

    (iii) $v^2 = u^2 + 2as$

    (iv) Distance travelled in nth second

$$S_n = u + \frac{a}{2}(2n - 1)$$

19. Equation of the path of projectile

$$y = x \tan \theta - \frac{g}{2u^2 \cos^2 \theta} \cdot x^2$$

20. Time of flight $T = \dfrac{2u \sin \theta}{g}$

21. Maximum height $H = \dfrac{u^2 \sin^2 \theta}{2g}$

22. Horizontal range $R = \dfrac{u^2 \sin 2\theta}{g} \quad \Rightarrow \quad R_{\max} = \dfrac{u^2}{g}$

23. Angular displacement $(\Delta\theta) = \dfrac{\text{Linear displacement}}{\text{Radius}}$

24. Angular velocity $(\omega) = \dfrac{\text{Angular displacement}}{\text{Time interval}}$

25. Angular acceleration $(\alpha) = \dfrac{\text{Change in angular velocity}}{\text{Time taken}}$

26. Angular momentum $L = mvr = m\omega r^2$

27. Relation between angular velocity and linear velocity; $v = r\omega$

28. Relation between angular acceleration and linear acceleration; $a = r\alpha$

29. Centripetal acceleration $a = \frac{v^2}{r} = r\omega^2$

30. Centripetal force $F = \frac{mv^2}{r} = mr\omega^2$

31. Kinematical equations in circular motion

    (i) $\omega = \omega_0 + \alpha t$

    (ii) $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

    (iii) $\omega^2 = \omega_0^2 + 2\alpha\theta$

32. Time period of conical pendulum,

$$T = 2\pi\sqrt{\frac{l\cos\theta}{g}}$$

33. Linear momentum $p = mv$

34. Impulse = Force × Time = Change in momentum

35. Force = Mass × Acceleration

36. Weight = Mass × Acceleration due to gravity

37. Thrust on the rocket at any instant

$$F = -u\frac{dM}{dt}$$

38. Velocity of rocket at any instant

$$v = v_o + u\log_e\left(\frac{M_o}{M}\right)$$

39. Limiting friction $(f_s) = \mu_s \times R$ (normal reaction)

40. Kinetic friction $(f_K) = \mu_K \times R$

41. Normal reaction of plane

$$R = mg\cos\theta$$

42. Maximum speed of a car on a level road;

$$v_{\max} = \sqrt{\mu_s Rg}$$

43. Maximum speed of a car on a banked road;

$$v_{\max} = \left(Rg \frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta} \right)^{1/2}$$

For $\mu_s = 0$, $\qquad v = \left(\frac{Rg}{\tan\theta} \right)^{1/2}$

44. Work = Force × Displacement × $\cos\theta$

45. Power = Rate of doing work = $\frac{\text{Work done}}{\text{Time taken}}$

46. Kinetic energy = $\frac{1}{2} mv^2 = \frac{p^2}{2m}$

47. Gravitational potential energy = mgh

48. Elastic potential energy = $\frac{1}{2} kx^2$

49. Electric potential energy = $\frac{1}{4\pi\varepsilon_o} \cdot \frac{q_1 q_2}{r}$

50. Work-Energy theorem

$$\begin{aligned} W &= \int_{v_1}^{v_2} F \cdot ds \\ &= \frac{1}{2} mv_2^2 - \frac{1}{2} mv_1^2 = K_f - K_i \\ &= \Delta \text{KE} \end{aligned}$$

51. Mass-Energy Equivalence

$$E = \Delta mc^2$$

52. Centre of mass of system of n-particles

$$\mathbf{r}_{\text{CM}} = \frac{m_1 \mathbf{r}_1 + m_2 \mathbf{r}_2 + \ldots + m_n \mathbf{r}_n}{m_1 + m_2 + \ldots + m_n} = \sum_{i=1}^{n} \frac{m_i \mathbf{r}_i}{\Sigma m_i}$$

53. Moment of force = Force × Perpendicular distance

54. Moment of inertia , $I = MK^2$

55. Radius of gyration , $K = \sqrt{\frac{r_1^2 + r_2^2 + \ldots + r_n^2}{n}}$

56. Torque = Moment of inertia × Angular acceleration

57. Rotational kinetic energy $(K) = \frac{1}{2} I\omega^2$

58. Gravitational force, $F = \frac{Gm_1m_2}{r^2}$

59. Relation between universal gravitational constant (G) and acceleration due to gravity (g);

$$g = \frac{GM}{R^2}$$

60. Gravitational field $E = \frac{F}{m} = \frac{GM}{r^2}$

61. Gravitational potential $V = \frac{W}{m} = -\frac{GM}{r}$

62. Gravitational potential energy $U = -\frac{GMm}{r}$

63. Time period of satellite $T = 2\pi\sqrt{\frac{r^3}{GM}}$

64. Orbital velocity, $v_o = \sqrt{\frac{GM}{r}} = R\sqrt{\frac{g}{R+h}}$

65. Energy of a satellite in orbit $E = -\frac{GMm}{2r}$

66. Binding energy $= \frac{+GMm}{2r}$

67. Escape velocity, $v_e = \sqrt{\frac{2GM}{R}} = \sqrt{2gR}$

$$= \sqrt{\frac{8\pi\rho GR^2}{3}}$$

68. Relation between escape velocity and orbital velocity;

$$v_e = \sqrt{2}\, v_o$$

69. Inertial mass $= \frac{\text{Force}}{\text{Acceleration}}$

70. Gravitational mass $= \frac{\text{Weight of body}}{\text{Acceleration due to gravity}}$

71. $\text{Stress} = \dfrac{\text{Restoring force}}{\text{Area}}$

72. $\text{Strain} = \dfrac{\text{Change in configuration}}{\text{Original configuration}}$

73. Hooke's Law

$\text{Stress} = \text{Modulus of elasticity} \times \text{Strain}$

74. Young's Modulus of elasticity

$$Y = \frac{\text{Normal stress}}{\text{Longitudinal strain}}$$

75. Bulk modulus of elasticity

$$K = \frac{\text{Normal stress}}{\text{Volumetric strain}}$$

76. Modulus of rigidity

$$\eta = \frac{\text{Tangential stress}}{\text{Shearing strain}}$$

77. $\text{Compressibility} = \dfrac{1}{\text{Bulk modulus}}$

78. $\text{Safety factor} = \dfrac{\text{Breaking stress}}{\text{Working stress}}$

79. Elastic potential energy in a stretched wire

$$= \frac{1}{2} (\text{stress}) \times \text{strain} \times \text{volume of the wire}$$

80. Elastic potential energy per unit volume

$$= \frac{1}{2} \times \text{stress} \times \text{strain}$$

$$= \frac{1}{2} \times \text{Young's modulus} \times (\text{strain})^2$$

81. Elastic potential energy of a stretched spring $= \dfrac{1}{2} kx^2$

82. Thermal stress $= \dfrac{F}{A} = Y\alpha\Delta\theta$

83. Interatomic force constant, $K = Yr_o$

84. Poisson's ratio $(\sigma) = \dfrac{\text{Lateral strain}}{\text{Longitudinal strain}}$

85. Depression of a cantilever, $\delta = \dfrac{wl^3}{3YI_G}$

2. Fluid Mechanics

86. Pressure exerted by the liquid $p = h\rho g$

87. Archimedes' principle $W = \dfrac{T}{\left(1 - \dfrac{\rho}{\sigma}\right)}$

88. Density of a mixture of substances, $\rho = \dfrac{m_1 + m_2}{\left(\dfrac{m_1}{\rho_1}\right) + \left(\dfrac{m_2}{\rho_2}\right)}$

89. Viscosity $(\eta) = -\dfrac{F}{A\left(\dfrac{dv}{dx}\right)}$

90. Viscous force $(F) = -\eta A \dfrac{dv}{dx}$

91. Variation of viscosity $\eta_t = \dfrac{\eta_o}{(1 + \alpha t + \beta t^2)}$

92. Poiseuille's formula $v = \dfrac{\pi}{8} \dfrac{pr^4}{\eta l}$

93. Rate of flow of liquid through a tube

$$v = \frac{\text{Liquid pressure}}{\text{Liquid resistance}}$$

94. Stoke' law, $F = 6\pi\eta r v$

95. Terminal velocity

$$v = \frac{2}{9} \cdot \frac{r^2 (\rho - \sigma) g}{\eta}$$

96. Critical velocity $v_c = \dfrac{k\eta}{r\rho}$

97. Reynold's number $K = \dfrac{v_c \rho r}{\eta}$

98. Equation of continuity

$$a_1 v_1 = a_2 v_2 \quad \Rightarrow \quad av = \text{constant}$$

99. Bernoulli's theorem

$$p + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$$

100. Rate of flow of liquid in venturimeter;

$$v = a_1 a_2 \sqrt{\frac{2gh}{a_1^2 - a_2^2}}$$

101. Surface tension $= \dfrac{\text{Force}}{\text{Length}}$

$$= \frac{\text{Work done}}{\text{Change in area}}$$

102. Surface energy = Surface tension × Increase in surface area.

103. Ascent of a liquid column in a capillary tube:

$$h = \frac{2s\cos\theta}{r\rho g} - \frac{r}{3}$$

104. Zurin's law, $Rh = \text{constant}$

$$\Rightarrow \qquad R_1 h_1 = R_2 h_2$$

3. Heat and Thermodynamics

105. Relation between different scales of temperatures

$$\frac{C}{100} = \frac{F - 32}{180} = \frac{K - 273}{100} = \frac{R}{80}$$

106. Thermo emf, $E = at + bt^2$

107. Thermal (heat) capacity = mc.

108. Water equivalent; $W = ms$ = heat capacity of a body

109. Latent heat, $Q = mL$

110. Principle of calorimetry

$$\text{Heat lost} = \text{Heat gained}$$

111. Coefficient of linear expansion

$$\alpha = \frac{\Delta l}{l \times \Delta t}$$

112. Coefficient of superficial expansion

$$\beta = \frac{\Delta A}{A \times \Delta t}$$

113. Coefficient of cubical expansion

$$\gamma = \frac{\Delta V}{V \times \Delta t}$$

114. Relation between coefficient of linear, superficial and cubical expansions

$$\beta = 2\alpha \text{ and } \gamma = 3\alpha$$

$$\therefore \quad \alpha : \beta : \gamma = 1 : 2 : 3$$

115. Coefficient of apparent expansion of a liquid

$$(\gamma_a) = \frac{\text{Apparent increase in volume}}{\text{Original volume} \times \text{rise in temperature}}$$

116. Coefficient of real expansion of a liquid

$$(\gamma_r) = \frac{\text{Real increase in volume}}{\text{Original volume} \times \text{rise in temperature}}$$

117. Boyle's law $pV = \text{constant}$

$$p_1V_1 = p_2V_2$$

118. Charles' law

$$\frac{V}{T} = \text{constant}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

119. Gay Lussac's or Regnault's law

$$\frac{p}{T} = \text{constant}$$

$$\Rightarrow \quad \frac{p_1}{T_1} = \frac{p_2}{T_2}$$

120. Standard gas equation

$$pV = nRT$$

121. van der Waals' gas equation

$$\left(p + \frac{a}{V^2}\right)(V - b) = RT$$

122. Pressure due to an ideal gas

$$p = \frac{1}{3}\frac{mn}{V}c^2 = \frac{1}{3}\rho c^2$$

123. Average speed of molecules of a gas

$$v = \sqrt{\frac{8kT}{\pi m}} = \sqrt{\frac{8RT}{\pi M}}$$

124. The most probable speed of molecules of a gas

$$v_{mp} = \sqrt{\frac{2kT}{m}} = \sqrt{\frac{2RT}{M}}$$

125. Degree of freedom

f or $N = 3$ (Number of particles) – Number of independent relation.

126. Specific heat of a gas at constant volume

$$C_V = \frac{f}{2}R$$

127. Specific heat of a gas at constant pressure

$$C_p = \left(\frac{f}{2} + 1\right)R$$

128. Ratio of specific heats of a gas at constant pressure and at constant volume

$$\gamma = \left(1 + \frac{2}{f}\right)$$

129. Mean free path $\lambda = \dfrac{kT}{\sqrt{2}\,\pi\,\sigma^2 p}$

130. Work done by a thermodynamic system

$$W = p \times \Delta V$$

131. First law of thermodynamics

$$\Delta Q = \Delta U + \Delta W$$

132. Efficiency of the cycle

$$\eta = \frac{\text{Work done}}{\text{Heat supplied}}$$

133. Slope of the adiabatic curve

$= \gamma \times$ slope of the isothermal curve

134. Isothermal modulus of elasticity $E_s = p$

135. Adiabatic modulus of elasticity $E_T = \gamma p$

136. Ratio between adiabatic and isothermal modulus

$$\frac{E_T}{E_S} = \gamma = \frac{C_p}{C_V}$$

137. Change in entropy $= \dfrac{\text{Heat supplied to the system}}{\text{Absolute temperature}}$

138. Thermal efficiency of a heat engine

$$\eta = \frac{\text{Work done / cycle}}{\text{Total amount of heat absorbed/ cycle}}$$

$$= 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$

139. Coefficient of performance of refrigerator

$$\beta = \frac{Q_2}{W}$$

$$= \frac{Q_2}{Q_1 - Q_2} = \frac{T_2}{T_1 - T_2}$$

140. Relation between efficiency (η) and coefficient of performance (β)

$$\beta = \frac{1 - \eta}{\eta}$$

141. Temperature gradient $= \dfrac{\text{Change in temperature}}{\text{Perpendicular distance}}$

$$= -\frac{\Delta\theta}{\Delta x}$$

142. The amount of heat flow in a conducting rod $Q = \dfrac{KA\Delta\theta t}{l}$

143. Thermal resistance $R = \dfrac{\Delta\theta}{H} = \dfrac{l}{KA}$

144. Ingen-Hausz experiment $\dfrac{k_1}{k_2} = \dfrac{l_1^2}{l_2^2}$

145. Emissivity (e) $= \dfrac{\text{Emissive power of the body } (e_\lambda)}{\text{Emissive power of a perfectly black body } (E_\lambda)}$

146. Kirchhoff 's law

$$\frac{e_\lambda}{(a_\lambda)} = \text{constant}\,(E_\lambda)$$

147. Stefan's law

$$E \propto T^4 \quad \Rightarrow \quad E = \sigma T^4$$

148. Newton's law of cooling

$$\frac{dT}{dt} = E\alpha\,(T - T_o)$$

149. Wien's Displacement law

$$\lambda_m\, T = \text{constant}\,(b)$$

150. Solar constant $S = \left(\frac{r}{R}\right)^2 \sigma T^4$

4. Oscillations and Waves

151. Frequency $= \frac{1}{\text{Time period}}$

152. Angular frequency

$$\omega = 2\pi\nu$$

153. Velocity of a particle executing SHM

$$v = \omega\sqrt{(a^2 - y^2)}$$

154. Acceleration of a particle executing SHM

$$\alpha = \omega^2 y$$

155. Time period in SHM

$$T = 2\pi\sqrt{\frac{\text{Displacement}}{\text{Acceleration}}}$$

156. Time period of the simple pendulum

$$T = 2\pi\sqrt{\frac{l}{g}}$$

157. Time period of the conical pendulum

$$T = 2\pi\sqrt{\frac{mr}{T\sin\theta}}$$

158. Time period of the compound pendulum

$$T = 2\pi \sqrt{\frac{I}{mgl}}$$

159. Time period of the torsional pendulum

$$T = 2\pi \sqrt{\frac{I}{C}}$$

160. Time period of the oscillation

$$T = 2\pi \sqrt{\frac{h}{g}}$$

161. Restoring force (F) = – Force constant of spring × distance

$$= -ky$$

162. Hooke's law, $mg = kl$

163. Time period of a loaded spring

$$T = 2\pi \sqrt{\frac{m}{k}}$$

164. Displacement of the damped oscillator

$$x = x_o e^{-bt/2m} \cos(\omega' t + \phi)$$

165. Mechanical energy E of the damped oscillator

$$E = \frac{1}{2} K x_0^2 e^{-bt/m}$$

166. Wave velocity, $v = f\lambda$

167. Particle velocity $= \frac{dy}{dt}$

168. Velocity of longitudinal (sound) waves $v = \sqrt{\frac{E}{\rho}}$

169. Newton's formula for isothermal process

$$v = \sqrt{\frac{E_S}{\rho}} = \sqrt{\frac{p}{\rho}}$$

170. Laplace's correction for adiabatic process

$$v = \sqrt{\frac{E_T}{\rho}} = \sqrt{\frac{\gamma p}{\rho}}$$

171. Speed of transverse motion

$$v = \sqrt{\frac{T}{m}}$$

172. Plane progressive simple harmonic wave

$$y = a \sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$$

$$= a \sin \frac{2\pi}{\lambda}(vt - x)$$

173. Intensity of constructive interference = (amplitude)^2

174. Equation of a stationary wave

$$y = 2a \cdot \sin \frac{2\pi t}{T} \cos \frac{2\pi x}{\lambda}$$

175. Melde's experiment

$$\text{Frequency of vibration of string} = \frac{\text{Frequency of tunning fork}}{2}$$

5. Electrostatics

176. Quantization of charge

$$Q = \pm ne$$

177. Coulomb's law of electrostatics

$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2}$$

178. Electric field intensity

$$\mathbf{E} = \lim_{q_0 \to 0} \frac{\mathbf{F}}{q_0}$$

179. Electric field intensity due to a point charge q

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$$

180. Electric potential $V = \dfrac{W}{q}$

181. Electric potential due to a point change q

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r}$$

182. Potential gradient $= \dfrac{dV}{dr}$

183. Relation between potential gradient and electric field intensity

$$E = -\left(\frac{dV}{dr}\right)$$

184. Electric flux $(\phi_E) = \mathbf{E} \cdot \mathbf{ds}$

185. Gauss' theorem

$$\phi_E = \oint_{\mathbf{s}} \mathbf{E} \cdot \mathbf{ds} = \frac{1}{\varepsilon_o} \Sigma q$$

186. Electric dipole moment

$$\mathbf{p} = q \times 2\mathbf{l}$$

187. Torque

$$\tau = Ep \sin\theta = \mathbf{p} \times \mathbf{E}$$

188. Work done of an electric dipole

$$W = pE(\cos\theta_1 - \cos\theta_2)$$

189. Potential energy of an electric dipole

$$U = -pE\cos\theta$$

190. Potential energy of charge system

$$U = \frac{1}{4\pi\varepsilon_o} \cdot \frac{q_1 q_2}{r}$$

191. Capacitance of a conductor $C = \dfrac{q}{V}$

192. Capacitance of an isolated spherical conductor

$$C = 4\pi\varepsilon_o R$$

6. Current Electricity

193. Electric current $I = \dfrac{q}{t}$

194. Current density $J = \dfrac{I}{A}$

195. Drift velocity, $v_d = \dfrac{eE\tau}{m} = \dfrac{eV\tau}{ml}$

196. Relation between electric current and drift velocity $v_d = \dfrac{I}{Ane}$

197. Mobility of electron $\mu = \dfrac{v_d}{E}$

198. Ohm's law; $I \propto V$

$\Rightarrow \qquad V = IR$

199. Electrical resistance $R = \dfrac{Ane^2\tau}{ml} = \dfrac{V}{I}$

200. Resistivity $\rho = \dfrac{m}{ne^2\tau}$

201. Electrical conductivity

$$\sigma = \frac{1}{\rho} = \frac{l}{RA} = \frac{ne^2\tau}{m}$$

202. Relation between current density (J) and electrical conductivity

$$J = \sigma E$$

203. Electromotive force (emf) of a cell

$$E = \frac{W}{q}$$

204. Terminal potential difference

$$V = \frac{W}{q}$$

205. Relation between E, V and internal resistance of a cell

$$E = V + Ir$$

206. Principle of Wheatstone bridge

$$\frac{P}{Q} = \frac{R}{S}$$

207. Principle of Meter bridge, $\dfrac{R}{S} = \dfrac{l_1 \text{ (length of wire)}}{100 - l_1}$

208. Principle of potentiometer

$$K = \frac{V}{L} = \frac{IR}{L} = \frac{E_o R}{(R_o + R)L}$$

209. Joule's law

$$H = I^2\, Rt = \frac{V^2 \cdot t}{R} \text{ joule}$$

or $$H = \frac{I^2 Rt}{4.18} = \frac{V^2 t}{4.18R} \text{ calories}$$

210. Electric power $P = VI = I^2R = \frac{V^2}{R}$

211. Electric energy

$$W = V.q = VIt = I^2Rt = \frac{V^2 t}{R}$$

212. Chemical equivalent $= \frac{\text{Atomic weight}}{\text{Valency}}$

213. Faraday's constant F = Avogadro's number × electric charge

214. Relation between neutral temperature (T_n) and temperature of inversion (T_i)

$$T_n = \frac{T_i + T_o}{2}$$

215. Thermoelectric power $S = \frac{dE}{dt} = \alpha + \beta T$

216. Peltier coefficient $\pi = \frac{\text{Peltier heat}}{\text{Charge flowing}}$

217. Thomson's coefficient $\sigma = \frac{dV}{dT}$

7. Magnetism EMI and AC

218. Biot Savart's law

$$\mathbf{dB} = \frac{\mu_o}{4\pi} \frac{\mathbf{I}d\mathbf{l} \times \mathbf{r}}{r^3} \quad \Rightarrow \quad dB = \frac{\mu_o}{4\pi} \cdot \frac{Idl \sin\theta}{r^2}$$

219. Magnetic dipole

$$|M| = NiA$$

220. Ampere's circuital law

$$\oint \mathbf{B} \cdot \mathbf{d}l = \mu_0 I$$

221. Magnetic field inside the turns of toroid

$$B = \mu_0 nI$$

222. Radius of circular path

$$r = \frac{mv}{Bq}$$

223. Cyclotron frequency $\upsilon = \frac{Bq}{2\pi m}$

224. Torque acting on a current carrying coil placed inside a uniform magnetic field

$$\tau = NBIA \sin\theta$$

225. Current sensitivity

$$I_s = \frac{\theta}{I} = \frac{NBA}{K}$$

226. Voltage sensitivity

$$V_s = \frac{\theta}{V} = \frac{NBA}{KR}$$

227. Principle of ammeter $S = \left(\frac{I_g}{I - I_g} \right) G$

228. Principle of voltmeter

$$V = I_g (G + R)$$

229. Coulomb's law

$$F = \frac{\mu_0}{4\pi} \cdot \frac{m_1 m_2}{r^2}$$

230. Magnetic dipole moment

$$\mathbf{M} = \mathbf{m}\,(2l)$$

231. Torque acting on a magnetic dipole

$$\tau = \mathbf{M} \times \mathbf{B} = MB \sin\theta$$

232. Potential energy of a magnetic dipole

$$U = W = -MB\cos\theta = -\mathbf{M} \cdot \mathbf{B}$$

233. Magnetic moment of an atom

$$M = \frac{1}{2} e\omega r^2 = n \frac{eh}{4\pi m}$$

234. Total intensity of earth's magnetic field

$$I = I_o\sqrt{1 + 3\sin^2\lambda}$$

235. Tangent law

$$B = H\tan\theta$$

236. Time period of vibrations

$$T = 2\pi\sqrt{\frac{I}{MH}}$$

237. Magnetic flux $\phi = \mathbf{B}\cdot\mathbf{A} = BA\cos\theta$

238. Magnetic induction $B = \frac{\phi}{A} = \mu_0(H + I)$

239. Magnetic permeability $\mu = \frac{B}{H}$

240. Magnetising force or Magnetic intensity, $H = \frac{B}{\mu}$

241. Intensity of magnetisation

$$\mathbf{I} = \frac{\mathbf{M}}{\mathrm{V}} = \frac{m}{A}$$

242. Magnetic susceptibility $\chi_m = \frac{I}{H}$

243. Relation between magnetic permeability and susceptibility

$$\mu = \mu_0(1 + \chi_m)$$

244. Curie law in magnetism, $\chi_m \propto \frac{1}{T}$

$$\chi_m T = \text{constant}$$

245. Motional emf $E = \mathbf{B}\cdot\mathbf{v}\times l = Bvl$

246. Coefficient of self-induction

$$L = \frac{\phi}{I} = \frac{\mu_0 N^2 A}{l} = \mu n^2 Al$$

247. Coefficient of mutual induction

$$M = \frac{\phi}{I}$$

248. Induced emf in the secondary coil

$$E = -M\frac{dI}{dt}$$

249. Coefficient of coupling

$$K = \sqrt{\frac{M}{L_1 L_2}}$$

250. Mutual induction of two long coaxial solenoids

$$M = \frac{\mu_0 N_1 N_2 A}{l} = \mu_0 n_1 n_2 A l$$

251. Growth of current in an inductor

$$I = I_0 (1 - e^{-Rt/L})$$

252. Decay of current in an inductor

$$I = I_0 e^{-Rt/T}$$

253. The instantaneous charge on a capacitor on charging

$$q = q_0 [1 - e^{-t/RC}]$$

254. The instantaneous charge on a capacitor in discharging

$$q = q_0 \ e^{-t/RC}$$

255. Instantaneous value of alternating current

$$I = I_0 \sin \omega t$$

256. Inductive reactance

$$X_L = L\omega = L \cdot 2\pi f = \frac{L \cdot 2\pi}{T}$$

257. Capacitive reactance

$$X_C = \frac{1}{C\omega} = \frac{1}{C \cdot 2\pi f} = \frac{T}{C \cdot 2\pi}$$

258. Impedance of an AC circuit

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

259. Average power in AC circuit

$$P_{\text{av}} = \frac{Vi \cos \theta}{2}$$

260. Resonant frequency $f = \dfrac{1}{2\pi\sqrt{LC}}$

261. Q-factor or sharpness at resonance

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

262. Induced emf produced by the AC generator

$$e = NBA\omega \sin \omega t = e_o \sin \omega t$$

263. Torque acting on a current carrying coil

$$\tau = NBIA \sin \theta$$

264. Efficiency of a motor

$$\eta = \frac{\text{Back emf}}{\text{Applied emf}} = \frac{E}{V}$$

265. Transformation ratio

$$K = \frac{N_S}{N_P} = \frac{E_S}{E_P} = \frac{I_P}{I_S}$$

8. Optics and Modern Physics

266. Mirror formula, $\dfrac{1}{f} = \dfrac{1}{v} + \dfrac{1}{u}$

267. Relation between focal length and radius of curvature $f = \dfrac{R}{2}$

268. The power of a mirror $P = \dfrac{1}{f(\text{metre})} = \dfrac{100}{f(\text{cm})}$

269. Newton's formula for a concave mirror

$$f = \sqrt{x_1 x_2}$$

270. Linear magnification $m = \dfrac{I}{O} = -\dfrac{v}{u}$

271. Areal magnification $= m^2 = \dfrac{\text{Area of image}}{\text{Area of object}}$

$$= \frac{-dv}{du} = \left(\frac{v}{u}\right)^2 = \left(\frac{f}{f-u}\right)^2 = \left(\frac{f-v}{u}\right)^2$$

272. Snell's law, $\frac{\sin i}{\sin r} = \text{constant } ({}_1\mu_2)$

273. Refractive index of a medium $(\mu) = \frac{c}{v}$

274. Relative refractive index

$$ {}_1\mu_2 = \frac{v_1}{v_2} $$

275. Cauchy's formula, $\mu = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4}$

276. Refractive index of denser medium

$$ \mu = \frac{1}{\sin C} $$

277. Lens formula, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

278. Lens Maker's formula, $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

279. Linear magnification for lens

$$ m = \frac{I}{O} = \frac{v}{u} $$

280. Focal length of a convex lens by displacement method

$$ f = \frac{a^2 - d^2}{4a} $$

281. Height of the object, $O = \sqrt{I_1 I_2}$

282. Prism formula

$$ \mu = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)} $$

283. Angular dispersion, $\theta = \delta_V - \delta_R = (\mu_V - \mu_R)A$

284. Dispersive power

$$ W = \frac{\theta}{\delta_Y} = \frac{(\mu_V - \mu_R)}{(\mu_Y - 1)} $$

285. f- number for a camera $= \dfrac{\text{Focal length of the lens } (F)}{\text{Diameter of the lens } (d)}$

286. Velocity of electromagnetic wave in vacuum

$$c = \frac{1}{\sqrt{\mu_o \varepsilon_o}}$$

287. Energy of a photon

$$E = h\nu = \frac{hc}{\lambda}$$

288. de-Broglie wave equation

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

289. Interference fringe width

$$\beta = \frac{D\lambda}{d}$$

290. Law of Malus, $I \propto \cos^2 \theta$

291. Brewster's law, $\mu = \tan i_p$

292. Specific charge of electron

$$\frac{e}{m} = \frac{E^2}{2VB^2}$$

293. Energy of a photon $E = h\nu$

294. Momentum of a photon

$$E = \frac{h\nu}{c} = \frac{h}{\lambda}$$

295. Dynamic or kinetic mass of photon

$$m = \frac{h\nu}{c^2} = \frac{h}{c\lambda}$$

296. Relation between work function, threshold frequency and threshold wavelength

$$\phi = h\nu_o = \frac{hc}{\lambda_{max}}$$

297. Einstein's photoelectric equation

$$(E_K)_{max} = h\nu - \phi = h(\nu - \nu_o)$$

298. Maximum kinetic energy of photo electrons

$$(E_k)_{\max} = \frac{1}{2} m v_{\max}^2 = eV_o$$

299. Compton effect $\Delta\lambda = \frac{h}{m_0 c}(1 - \cos\phi)$

300. Kinetic energy of recoil electron

$$E_K = \frac{hc}{\lambda} - \frac{hc}{\lambda'}$$

301. de-Broglie wavelength

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2meV}}$$

302. Bragg's law,

$$2d \sin\theta = n\lambda$$

303. Moseley's law,

$$\nu = a(z - b)^2$$

304. Distance of closest approach

$$r_0 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2ze^2}{E_K}$$

305. Impact parameter

$$b = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Ze^2 \cot\left(\frac{\theta}{2}\right)}{E_K}$$

306. Rutherford's scattering formula

$$N(\theta) = \frac{N_i n t Z^2 e^4}{(8\pi\varepsilon_0)^2 r^2 E^2 \sin^4\left(\frac{\theta}{2}\right)}$$

307. Radius of orbit of electron

$$r = \frac{n^2 h^2}{4\pi^2 mkZe^2}$$

308. Velocity of electron in any orbit

$$v = \frac{2\pi\, kZe^2}{nh}$$

309. Frequency of electron in any orbit

$$\nu = \frac{kZe^2}{nhr} = \frac{4\pi^2 Z^2 e^4 mk^2}{n^3 h^3}$$

310. Kinetic energy of electron in any orbit

$$E_k = \frac{2\pi^2 me^4 Z^2 k^2}{n^2 h^2} = \frac{13.6Z^2}{n^2} \text{ eV}$$

311. Potential energy of electron in any orbit

$$E_p = -\frac{4\pi^2 me^4 Z^2 k^2}{n^2 h^2} = -\frac{27.2Z^2}{n^2} \text{ eV}$$

312. Total energy of electron in any orbit

$$E = \frac{-2\pi^2 me^4 Z^2 k^2}{n^2 h^2} = \frac{-13.6Z^2}{n^2} \text{ eV}$$

313. Radius of the nucleus $R \propto A^{1/3}$

$$\Rightarrow \qquad R = R_0 A^{1/3}$$

314. Nuclear density

$$\rho = \frac{\text{Mass of nucleus}}{\text{Volume of nucleus}} = \frac{3m}{4\pi R_0^3}$$

315. Mass defect $\Delta m = M - m = [Zm_p + (A - Z)m_n - m_N]$

316. Nuclear binding energy $= (\Delta m)c^2$

$$= [Zm_p + (A - Z)m_n - m_N]c^2$$

317. Nuclear binding energy per nucleon

$$= \frac{\text{Nuclear binding energy}}{\text{Total number of nucleons}}$$

$$= \frac{[Zm_p + (A - Z)m_n - m_N]c^2}{A}$$

318. Packing fraction P

$$= \frac{(\text{Exact nuclear mass}) - (\text{Mass number})}{\text{Mass number}}$$

319. Rate of disintegration

$$\frac{-dN}{dt} \propto N \quad \Rightarrow \quad \frac{-dN}{dt} = \lambda N$$

320. Relation between half-life and disintegration constant

$$T = \frac{\log_e 2}{\lambda} = \frac{0.6931}{\lambda}$$

321. Activity of a radioactive element

$$R = \left(\frac{-dN}{dt} \right)$$

9. Semiconductor

322. Electrical conductivity of extrinsic semiconductor

$$\sigma = \frac{1}{\rho} = e\,(n_e \mu_e + n_h \mu_h)$$

323. Resistance of diode $R = \dfrac{V}{I}$

324. AC current gain $(\alpha_{AC}) = \dfrac{\Delta I_c}{\Delta I_e}$

325. AC voltage gain $(A_V) = \dfrac{\text{Output voltage}}{\text{Input voltage}} = \alpha_{AC} \times$ resistance gain

$$= \alpha_{AC} \times \frac{R_o}{R_i}$$

326. AC power gain $= \dfrac{\text{Change in output power}}{\text{Change in input power}}$

327. Relation between the current gain of common base and common emitter amplifier

$$\beta = \frac{\alpha}{1 - \alpha} = \frac{I_C}{I_B}$$

328. Displacement current,

$$I_D = \varepsilon_0 \cdot \frac{d\phi_E}{dt}$$

329. Ampere-Maxwell law

$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 (I + I_D)$$

330. Poynting vector

$$\mathbf{S} = \frac{1}{\mu_0} \mathbf{E} \times \mathbf{B}$$

331. Average electric energy density

$$U_E = \frac{1}{2}\,\varepsilon_0 E^2 = \frac{1}{4}\,\varepsilon_0 E_0^2$$

332. Average magnetic energy density

$$U_B = \frac{1}{2}\,\frac{B^2}{\mu_0} = \frac{1}{4}\,\frac{B_0^2}{\mu_0}$$

333. Critical frequency $\nu_c = 9\,(N_{\max})^{1/2}$

334. Skip distance $(D_{\text{skip}}) = 2h\left(\frac{v_{\max}}{v_c}\right)^2 - 1$

335. Effective range in space wave propagation

$$d = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

336. Principle of meter bridge or slide wire bridge

$$\frac{P}{Q} = \frac{l}{100 - l} = \frac{R}{S}$$