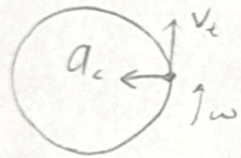
Formulas

1. $\bar{v} = \frac{\Delta x}{\Delta t}$; $v(t) = \frac{dx}{dt}$

2. $\bar{a} = \frac{\Delta v}{\Delta t}$; $a(t) = \frac{d^2x}{dt^2}$

3. $x(t) = x_0 + v_0 t + \frac{1}{2}at^2$
   ↳ constant acceleration

4. $v^2 = v_0^2 + 2a(x - x_0)$
   ↳ constant acceleration



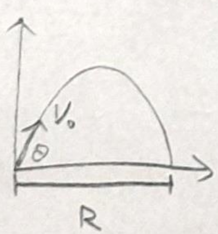
5. $a_c = \frac{v_t^2}{R} = R\omega^2$
   ↳ centripetal acceleration of circular motion

6. $\vec{r}_{AB} = \vec{r}_{AC} + \vec{r}_{CB}$
   ↳ relative motion in vectors

7. $\vec{r}(t) = \vec{r}_0 + \vec{v}_0 t + 2\vec{a}t^2$
   ↳ constant acceleration in vectors

8. $T = \frac{2v_0 \sin\theta}{g}$
   ↳ projectile motion duration

9. $R = \frac{v_0^2 \sin 2\theta}{g}$
   ↳ projectile motion range



10. $F = ma$

11. $\vec{F} = m\vec{a}$ → vector notion

12. $F = -kx$ → force produced by a spring with constant k

13. $f_s \leq \mu_s N$; $f_k = \mu_k N$
    ↳ static and kinetic friction

14. $\Delta W = Fd = F\Delta x$

15. $\Delta K = K_2 - K_1 = \Delta W$
    ↳ work-energy thereom

16. $U(x) = \int F(x)\,dx$
    ↳ potential energy of conservative force

17. $U_g(y) = mgy$ → gravitational potential energy

18. $U_s(y) = \frac{1}{2}kx^2$ → spring potential energy

19. $\Delta K = K_2 - K_1 = \int_{\vec{x}_1}^{\vec{x}_2} \vec{F}(\vec{x}) \cdot d\vec{x}$ → vector form

20. $\frac{\partial F_x}{\partial y} = \frac{\partial F_y}{\partial x} \Leftrightarrow F$ is conservative

21. $\frac{dA}{dt} = \text{constant}$ → a planet in orbit

Formulas

22. $\frac{R^3}{T^2} = \frac{GM}{4\pi^2}$ → planet orbiting M

23. $F_g = G\frac{Mm}{r^2}$

24. $V_t = \sqrt{\frac{GM}{R}}$

↳ velocity of planet orbiting M

25. $U_g = -\frac{GMm}{r}$

↳ general gravitational potential energy

26. $X_{com} = \frac{\sum m_i x_i}{\sum m_i}$ → center of mass

27. $F = M\ddot{X}_{com} = M\frac{d^2X}{dt^2}$

28. $\vec{R}_{com} = \frac{\sum m_i \vec{r}_i}{\sum m_i}$ → vector form

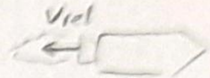
29. $\vec{F} = M\ddot{\vec{R}}_{com} = M\frac{d^2\vec{R}}{dt^2}$

30. $p = mV$

31. $\sum P_{before} = \sum P_{after} \Leftrightarrow F_{ext} = 0$

↳ law of conservation of momentum

32. $V_f - V_i = V_{rel} \ln \frac{M_i}{M_f}$



↳ rocket equation

33. $u_1 = \frac{m_1 - m_2}{m_1 + m_2}V_1 + \frac{2m_2}{m_1 + m_2}V_2$

$u_2 = \frac{m_2 - m_1}{m_1 + m_2}V_2 + \frac{2m_1}{m_1 + m_2}V_1$

↳ totally ellastic collision

34. $\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

↳ constant angular acceleration

35. $I = \int r^2 dm$ → moment of inertia

36. $K_r = \frac{1}{2}I\omega^2$ → rotational kinetic energy

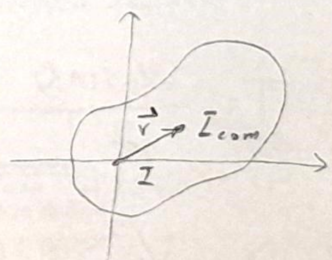
37. $L = I\omega = rp\sin\theta$

38. $F = \frac{dP}{dt}$; $\tau = \frac{dL}{dt}$

39. $\tau = rF\sin\theta = I\alpha$

40. $oW = \tau\theta$

41. $I = I_{com} + M(\vec{r})^2$



↳ parallel-axis thereom

42. $K = K_t + K_r = \frac{1}{2}mV_{com}^2 + \frac{1}{2}I_{com}\omega^2$

Formulas

43. $S = r\theta$

44. $V_T = r\omega$

45. $a_T = r\alpha$

46. $\bar{\omega} = \frac{\Delta\theta}{\Delta t}$; $\omega(t) = \frac{d\theta}{dt}$

47. $\bar{\alpha} = \frac{\Delta\omega}{\Delta t}$; $\alpha(t) = \frac{d^2\theta}{dt^2}$

48. $\sum L_{before} = \sum L_{after} \Leftrightarrow \tau_{ext} = 0$

↳ low of conservation of anguler momentum

49. $\vec{\tau} = \vec{r} \times \vec{F}$

50. $\vec{L} = \vec{r} \times \vec{P}$

51. $\omega_P = \frac{mgL}{I\omega}$

↳ angular frequency of gyroscope precession

52. $x(t) = A\cos(\omega t + \phi)$; $\omega = \sqrt{\frac{k}{m}}$

↳ simple harmonic motion

53. $V(t) = A\omega \sin(\omega t + \phi)$

54. $a(t) = -A\omega^2 \sin(\omega t + \phi)$

55. $E_{SHM} = \frac{1}{2} k A^2$ → energy of S.H.M

56. $\theta(t) = \theta_0 \cos(\omega t + \phi)$; $\omega = \sqrt{\frac{K}{I}}$

↳ angular oscillation

57. $\omega_{pendulum} = \sqrt{\frac{g}{l}}$

↳ angular frequency of pendulum

58. $x(t) = Ae^{i\omega_0 t} + Be^{-i\omega_0 t}$

↳ a general solution to S.H.M.

59. $x(t) = Ae^{-\frac{b}{2m}t} \cos(\omega' t + \phi)$; $\omega' = \sqrt{\omega_0^2 - (\frac{b}{2m})^2}$

↳ damped S.H.M. with $f = bv$

60. $x(t) = \frac{(\frac{F_0}{m}) \cos(\omega t - \phi)}{\sqrt{(\omega_0^2 - \omega^2) + \omega^2 (\frac{b}{m})^2}}$

↳ damped S.H.M driven by $F_0 \cos \omega t$

61. $\frac{\partial^2 \psi}{\partial x^2} = \frac{1}{v^2} \frac{\partial^2 \psi}{\partial t^2}$ → wave equation

62. $V = \sqrt{\frac{T}{\mu}}$; $\mu = \frac{m}{L}$ → wave speed of string wave

63. $\psi(x,t) = A\cos(kx - \omega t + \phi)$; $k = \frac{\omega}{v}$

↳ a solution to the wave equation

64. $\psi(x,t) = F(x - vt)$

↳ a general solution to the wave equation

Formulas

65. $k = \frac{2\pi}{\lambda}$; $\omega = \frac{2\pi}{T}$

↳ parameters of the wave function

66. $E = \frac{1}{2}\mu\, dx\, (A\omega)^2$

↳ energy of a sinusoidal wave

67. $u = \frac{E}{L} = \frac{1}{2}\mu(A\omega)^2$

↳ energy density of a sinusoidal wave

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

↳ average power of a sinusoidal wave

69. $\beta = 10\log\frac{I}{I_0}$; $I_0 = 10^{-12}\ W/m^2$

↳ sound intensity (in decibels)

70. $\lambda' = \lambda \mp \frac{u}{f}$

↳ doppler effect (source moving at velocity u)

71. $f' = f(1 \pm \frac{u}{v})$

↳ doppler effect (observer moving at velocity u)

72. $\omega = \omega_1 - \omega_2$

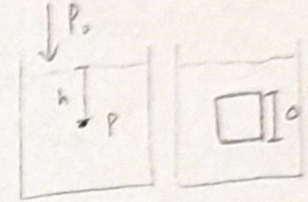
↳ beat frequency of two waves interfering

73. $\Psi(x,t) = 2A\sin(kx)\sin(\omega t)$

↳ standing wave function

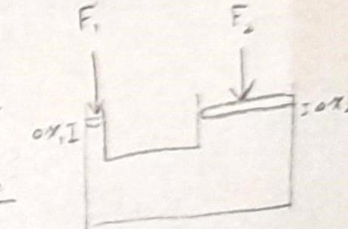
74. $P = \frac{F}{A}$

75. $\rho = \frac{M}{V}$



76. $\Delta P = \rho g \Delta h$

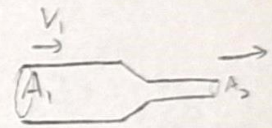
77. $P = P_0 + \rho g \Delta h$



78. $F = \rho g h A = \rho g V = M_{fluid}\, g$

79. $F_1\Delta x_1 = F_2\Delta x_2 = W$; $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

↳ hydraulic press



80. $A_1 v_1 = A_2 v_2$ → fluid continuity

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

↳ bernouli's principle

82. $T_A = T_B$ & $T_B = T_C \Rightarrow T_A = T_C$

↳ zeroth law of thermodynamics

83. $Q = Cm\Delta T$ → heat

84. $\Delta L = \alpha L \Delta T$ → linear expansion

85. $\Delta V = \beta V \Delta T$ → volume expansion

86. $\frac{dQ}{dt} = -KA\frac{\Delta T}{L}$ → thermal conductivity

Formulas

87. $PV = nRT$

88. $PV = NkT = \frac{2}{3} N\bar{K}$

89. $\bar{K} = \frac{3}{2} kT$

90. $P(v) = v^2 e^{\frac{-mv^2}{kT}}$

↳ possibility of gas atom velocity

91. $U = \frac{3}{2} NkT = \frac{3}{2} PV$ → internal energy

92. $\Delta U = Q - \Delta W$

↳ first law of thermodynamics

93. $C_V = \frac{3}{2} R$

↳ specific heat of constant volume process

94. $C_P = \frac{5}{2} R$

↳ specific heat of constant pressure process

95. $\eta = \frac{Q_1 - Q_2}{Q_1}$

↳ efficiency of heat engines

96. $\eta = 1 - \frac{T_2}{T_1}$

↳ efficiency of carnot cycle

97. $\Delta S = \frac{\Delta Q}{T}$ → entropy

98. $S_2 - S_1 = nR \ln \frac{V_2}{V_1}$

99. $\Delta S_{universe} \geq 0$

↳ second law of thermodynamics

100. $S = k \ln \Omega$

↳ Ω is the number of arrangements possible

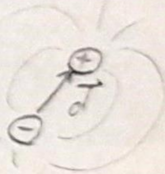
101. $F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$ → Coulomb's law

102. $\vec{F} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \hat{r} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^3} \vec{r}$

103. $\vec{F} = q\vec{E}(\vec{r})$

104. $\vec{E} = \frac{q\vec{r}}{4\pi\varepsilon_0 r^3}$ → electric field

105. $\vec{p} = q\vec{d}$ → electric dipole moment



106. $\vec{\tau} = \vec{p} \times \vec{E}$

↳ torque of an electric dipole in an uniform field

107. $U = -\vec{p} \cdot \vec{E}$

↳ potential energy of an electric dipole in an uniform field

Formulas

108. $\Phi_E = \dfrac{q_{enc}}{\varepsilon_0}$ → electric flux

109. $\oiint \vec{E} \cdot d\vec{A} = \dfrac{q_{enc}}{\varepsilon_0}$

↳ Gauss' Law

110. $E(r) = \dfrac{\lambda}{2\pi\varepsilon_0 r}$

↳ electric field of a long wire of charge

111. $E(r) = \dfrac{\sigma}{2\varepsilon_0}$

↳ electric field of a sheet of charge

112. $E(r) = \dfrac{Qr}{4\pi\varepsilon_0 R^3}$

↳ electric field of the inside of a uniform sphere

113. $\Delta U(r) = -q\int \vec{E}(\vec{r}) \cdot d\vec{r}$

↳ electric potential energy

114. $\Delta V(r) = -\int \vec{E} \cdot d\vec{r}$ → electric potential

115. $C = \dfrac{Q}{V}$ → capacitance

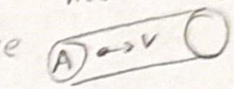
116. $C = \dfrac{\varepsilon_0 A}{d}$ → parallel-plate capacitor

117. $C = \dfrac{4\pi\varepsilon_0 ab}{b-a}$ → sphere capacitor

118. $U = \frac{1}{2}CV^2 = \dfrac{1}{2C}Q^2$ → potential energy

119. $I = Avne$ → current in a wire

n = # e = charge



120. $J = \dfrac{I}{A} = nev$ → current density

121. $I = \int \vec{J} \cdot d\vec{A}$

122. $\bar{v} = \dfrac{eE}{m}\tau$ → carrier drift speed

123. $J = ne\dfrac{eE}{m}\tau = \sigma E$ → conductivity

124. $I = JA = \sigma AE = \sigma A\dfrac{V}{L} = \dfrac{V}{R}$ → resistance

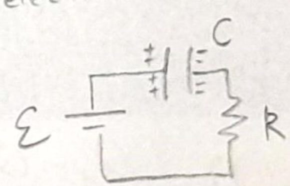
125. $V = IR = I\rho\dfrac{L}{A}$ → Ohm's Law

126. $Q(t) = Q_0 e^{-\frac{t}{RC}}$

↳ RC circuit

127. $\mathcal{E} = \int \vec{E} \cdot d\vec{r}$ → emf, electromotive force

128. $Q(t) = \mathcal{E}C\left[1 - e^{-\frac{t}{RC}}\right]$



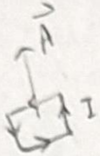
↳ RC circuit with batteries

129. $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$ → electromagnetic force

130. $d\vec{F} = I\,d\vec{l} \times \vec{B}$ → magnetic force

Formulas

131. $\vec{\mu} = \vec{A} I$ → magnetic dipole

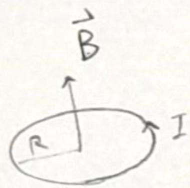


132. $\vec{\tau} = \vec{\mu} \times \vec{B}$ → torque on a dipole

133. $U = -\vec{\mu} \cdot \vec{B}$ → potential energy of a dipole

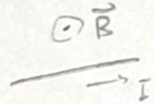
134. $d\vec{B} = \frac{\mu_0 I}{4\pi} \frac{d\vec{l} \times \hat{r}}{|\Delta \vec{r}|^2}$

↳ Biot-Savart law



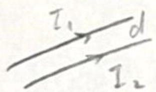
135. $B(z) = \frac{\mu_0 I R^2}{2(z^2+R^2)^{\frac{3}{2}}}$

↳ magnetic field of a circular current



136. $B(z) = \frac{\mu_0 I}{2\pi z}$

↳ magnetic field of an infinite wire



137. $F = \frac{\mu_0 I_1 I_2}{2\pi d}$

↳ magnetic force of two parallel wires

138. $\oint \vec{B} \cdot d\vec{r} = \mu_0 I_{enc}$ → Ampere's law

139. $B = \mu_0 n I$; $n = \frac{N}{L}$

↳ magnetic field inside a solenoid

140. $B = \frac{\mu_0 N I}{2\pi R}$

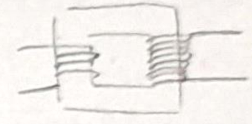
↳ magnetic field inside a torioid

141. $\oint \vec{E} \cdot d\vec{r} = -\frac{d\Phi_B}{dt}$ → Faraday's law

142. $\oint \vec{E} \cdot d\vec{r} = -\iint_S \frac{\partial \vec{B}}{\partial t} \cdot d\vec{A}$ → Faraday's law

143. $\mathcal{E} = M \frac{dI}{dt}$ → mutual induction

144. $\frac{\mathcal{E}_1}{\mathcal{E}_2} = \frac{N_1}{N_2}$ → transformer



145. $\mathcal{E} = L \frac{dI}{dt}$ → self inductance

146. $U = \frac{1}{2} L I^2$ → potential energy of an inductor

147. $U = \frac{B^2}{2\mu_0} \cdot \text{Volume}$

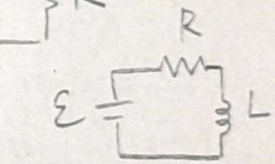
↳ potential energy of a solinoid inductor

148. $I(t) = I_0 e^{-\frac{t}{L/R}}$

↳ LR circuit

149. $I(t) = \frac{\mathcal{E}}{R} e^{-\frac{t}{L/R}}$

↳ LR circuit with batteries



150. $Q(t) = Q_0 e^{-\frac{Rt}{2L}} \cos(\omega' t + \phi)$; $\omega' = \sqrt{\omega^2 - \left(\frac{R}{2L}\right)^2}$

↳ LCR circuit

151. $I(t) = \frac{V_0}{\sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}} \cos(\omega t - \phi)$

↳ LCR circuit driven by AC

Formulas

141. $\oint \vec{B} \cdot d\vec{r} = \mu_0 I + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$

↳ Ampere - Maxwell law

142. $\frac{\partial^2 \vec{E}}{\partial y^2} - \mu_0 \varepsilon_0 \frac{\partial^2 \vec{E}}{\partial t^2} = 0$

↳ electromagnetic wave equation

143. $C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ → speed of light

144. $\begin{cases} \vec{E} = E_0 \sin(ky - \omega t)\,\hat{k} \\ \vec{B} = B_0 \sin(ky - \omega t)\,\hat{i} \end{cases}$; $\omega = kC$

145. $E_0 = \frac{C^2}{\omega} k B_0 = \frac{\omega}{k} B_0 = C B_0$

146. $U_E = \frac{\varepsilon_0 E^2}{2}$; $U_B = \frac{B^2}{2\mu_0}$

↳ energy of electromagnetic wave

147. $u = \frac{\varepsilon_0 E_0^2}{2}$ → energy density

148. $\bar{I} = \frac{E_0 B_0}{2\mu_0}$ → intensity

149. $n_1 \sin\theta_1 = n_2 \sin\theta_2$ → snell's law

150. $y^2 = 4xf$ → parabolic mirror

151. $y^2 \doteq 2xR$ → spherical mirror

152. $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$; $\frac{h_1}{h_2} = \frac{u}{v}$

↳ lens