LIST OF

FORMULAS

PHY

LIST OF FORMULA PHY

notes by asmarazale (ASiD 19/20)

CHAPTER 5 : Energy

① Work

$W = F_x d$ (Force acting; d = displacement)

$= (F\cos\theta)\Delta x$

↳ $\cos 90° = 0$

② Energy

$KE = \frac{1}{2}mv^2$

kinetic energy (m = mass, v = velocity)

$W_c + W_{nc} = \Delta KE$ (conservative force; non-cons)

$W_{net} = \Delta KE$

$F\Delta x = KE_f - KE_f$

$= \frac{1}{2}mv_i^2 - \frac{1}{2}mv_f^2$

gravitional potential energy

$PE = mgy$ → $(y_f - y_i)$ displacement vertically

g = gravitational acceleration

change in potential energy $= PE_f - PE_i$

③ Work energy theorem

$W_{nc} = (KE_f - KE_i) + (PE_f - PE_i)$ (F constant)

conservation of

④ Mechanical energy

$W_{nc} = 0$

$KE_i + PE_i = (KE_f + PE_f)$

$\frac{1}{2}mv_i^2 + mgy_i \quad \frac{1}{2}mv_f^2 + mgy_f$

⑤ Spring potential energy

$F_s = -kx$

↳ shows F opposite direction of x

$PE_s = \frac{1}{2}kx^2$ (k = spring constant)

work energy theorem

$W_{nc} = (KE_f - KE_i) + (PE_{g_f} - PE_{g_i}) + (PE_{s_f} - PE_{s_i})$

conservation of energy

$(KE + PE_g + PE_s)_f = (KE + PE_g + PE_s)_i$

⑥ Power

$P = \frac{W}{t} = \frac{E}{t}$

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CHAPTER 6 : Momentum and Collisions

① $\vec{p} = mv$ (linear momentum; m = mass, v = velocity)

$p_x = mv_x$

$p_y = mv_y$

newton's second law

② $F = ma$ (a = acceleration)

③ $I = Ft = mv - mu$ (I = impulse; F = Force applied)

④ $F = \frac{p}{t} = \frac{mv - mu}{t}$ (p = momentum; Force applied to change momentum)

$$m_1V_1 + m_2V_2 = 0$$

⑤ elastic collision

* kinetic energy are conserved.

$$m_1V_{01} + m_2V_{02} = m_1V_1 + m_2V_2$$

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2V_2^2$$

⑥ inelastic collision

$$m_1V_{01} + m_2V_{02} = (m_1 + m_2)V$$

(V = same velocity after collision)

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CHAPTER 7 : Rotational Motion & Law of Gravity

① $360^\circ = 2\pi = 1\text{ rev}$

② $\omega = \frac{\Delta\theta}{\Delta t}$ — ω: angular speed; θ: angular displacement

③ $\alpha = \frac{\Delta\omega}{\Delta t}$ — angular acceleration

④ $s = \theta r$ — displacement of circumference; r: radius

⑤ $v_t = \omega r$ — tangentional speed

⑥ $a_t = \alpha r$ — tangention accelerational

⑦ $a_{cp} = r\omega^2$ — centripetal acceleration

*$a_{cp} = \frac{v^2}{r}$

⑧ acceleration constant

$$\omega = \omega_0 + \alpha t$$

$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$$

$$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\Delta\theta = \frac{1}{2}(\omega_0 + \omega)t$$

⑨ $F_{cp} = m a_{cp}$* $= \frac{mv^2}{r}$

F_{cp}: force that keep object in circular path

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$\tau = F$
$\omega = v$
$I = m$
$L = p$

CHAPTER 8 : Rotational Equilibrium & Rotational Dynamics

① $\tau = r F \sin\theta$

Torque; r = radius; $F \sin\theta$ → force applied

* anticlockwise → +ve
clockwise → −ve

② $\tau = rF = 0$

Torque in condition of equilibrium (no radius / radius = 0)

③ $\tau_1 = m_1 g x_1$ — x_1 = x-coordinate

$$x_{cg} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

center gravity

④ $I = \sum m r^2$

Inertia; m in kg; r in m

⑤ $\sum \tau = I\alpha$

Net Torque; I = Inertia; α = angular acceleration.

$F = ma$

⑥ $L = I\omega$

Angular momentum

$p = mv$

⑦ $\sum \tau = \frac{\Delta L}{\Delta t}$

$F = \frac{p}{t}$

$= \frac{mv - mu}{t}$

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CHAPTER 9 : Solids and Fluids

$\rho = \frac{m}{V}$, $m = \rho V$

1 $F_B = W_f = m_f g$

- F_B: Bouyant Force
- W_f: Weight of fluids
- m_f: mass of fluids displaced by object
- g: gravitational acceleration

$F_B = \rho V g$

- ρ: density
- V: volume (of water displaced) of fluid displaced by object

when.....

$W = F_B$	⇒ float
$W > F_B$	⇒ sink

(kalau totally submerged V = volume object)

2 $F = Y\left(\frac{\Delta L}{L_0}\right)A$

- F: Force required to change the length of solid
- Y: young modulus
- ΔL: change in length solid
- L_0: length initial solid
- A: Area of solid

3 $F = S\left(\frac{\Delta x}{h}\right)A$

- F: Force required to deform solid
- S: sheer modulus
- Δx: sheer deformation
- h: height of solid
- A: Area of solid

4 $\Delta P = -B\left(\frac{\Delta V}{V_0}\right)$

- ΔP: Pressure required to change volume of solid
- B: Bulk modulus
- ΔV: Change in volume
- V_0: initial volume of solid

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CHAPTER 10 : Thermal physics

① Convert from Celcius to Ferenheit

$$T_F = \frac{9}{5}(T_c) + 32$$

$$T_k = T_c + 273.15$$

② Linear expansion

$$\Delta L = \alpha L_0 \Delta T$$

- α → coefficent of linear expansion
- L_0 → initial length of object being heated
- ΔT → $T_f - T_i$

③ Area expansion

$$\Delta A = \gamma A_0 \Delta T = 2\alpha A_0 \Delta T$$

- A_0 → initial area

④ Volume expansion

$$\Delta V = \beta V_0 \Delta T = 3\alpha V_0 \Delta T$$

- β → coefficent of volume expansion
- V_0 → initial volume

* higher α,
→ higher expansion & shrink more

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CHAPTER 11 : Energy in Thermal processes

① Heat capacity

$$Q = C\Delta T$$

- Q: energy released/absorbed
- C: heat capacity ($J\,{}^\circ C^{-1}$)
- ΔT → $T_f - T_i$

② Specific Heat

$$Q = mc\Delta T$$

- c: ($J\,kg^{-1}\,{}^\circ C^{-1}$)
- m: mass of substance (kg)

③ calorimeter

$$-Q_{hot} = Q_{cold} \qquad Q_1 + Q_2 = 0$$

④ latent heat and phase change

$$Q = mL$$

- L: latent heat
- phase change → boiling point or freezing point

⑤ Energy transfer

$$P = \frac{Q}{t} = kA\left(\frac{T_{hot} - T_{cold}}{L}\right)$$

- P: power
- k: thermal conductivity
- A: area experienced heat transfer
- L: Thickness/length of object

$$Q = kA\left(\frac{\Delta T}{L}\right)t$$

- Q: heat flow by conduction

* $k\uparrow$: good conductor
$k\downarrow$: good insulator

$$e = \frac{W}{Q_h}$$

- W: output work
- Q_h: input heat

* doesn't has change in temp but still absorbed or released energy

1 cal = 4.186 J

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CHAPTER 12 : The Laws of Thermodynamic

① $W = -W_{env}$

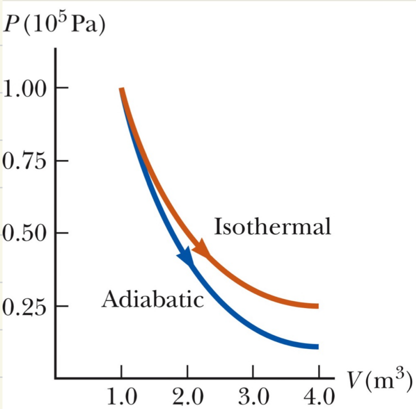
- W: work ON system
- W_{env}: work BY system

② $W = -P\Delta V$

- W: work on gas/system
- P: pressure (constant)
- ΔV: change in volume

$$\Delta U = W + Q$$

$$nC_v\Delta T = -PV + Q$$



③ First Law of Thermodinamic

$$\Delta U = Q + W$$

- W: +ve : on, -ve : by
- Q: heat
  - +Q : into
  - -Q : removed
- ΔU: $\Delta T = 0$, $U = 0$
  - ΔU = +ve, temp ↑
  - ΔU = -ve, temp ↓

$$\Delta U = nC_v\Delta T$$

C_v: molar heat capacity

$$C_v = \frac{3}{2}R$$

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CHAPTER 12 : The Laws of Thermodynamic

ISOBARIC

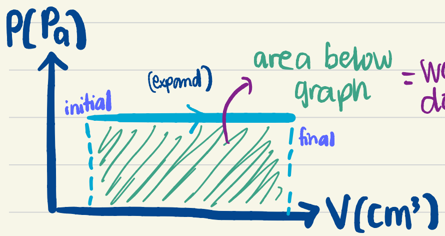
- pressure constant

$$Q = \frac{5}{2} nRT$$
$$= nC_v \Delta T$$

Compress : ← work done on

expand : → workdone by

depends on arrow

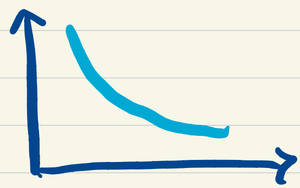


ADIABATIC

- no heat transfer

$$\Delta U = \cancel{Q} + W$$
$$\Delta U = W \rightarrow PV^{\gamma}$$

$$* \ \gamma = \frac{C_p}{C_v}$$



ISOVOLUMETRIC

- volume constant

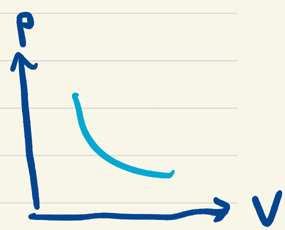
$$\Delta U = Q + \cancel{W}$$
$$\Delta U = Q$$
$$= nC_v \Delta T$$

ISOTHERMAL

- temp constant

$$\cancel{\Delta U} = Q + W$$
$$0 = Q + W$$
$$Q = -W$$
$$= W_{env}$$
$$= nRT \ln\left(\frac{V_f}{V_i}\right)$$

$nRT \rightarrow PV = nRT$



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* change calculator to rad mode

CHAPTER 13 : Vibrations and Waves

Hooke's law

① $F_s = -kx$ = ma

- spring constant: k
- Spring force: F_s
- −: x opposite with spring force
- x: displacement from equilibrium position

② $f = \frac{1}{T}$

- Frequency: f
- Period: T

Simple Harmonic motion

③ $F = -kx = ma$

④ $PE_s = \frac{1}{2}kx^2$

Elastic potential energy

during x = 0, V = max (spring at rest)

→ $KE = \frac{1}{2}mv^2$ ⟨max⟩

x = max, V = 0 (before change direction)

→ $PE = \frac{1}{2}kx^2$ ⟨max⟩

⑤ $V = \pm\sqrt{\frac{k}{m}(A^2 - x^2)}$

- V: velocity object in any position
- A: amplitude
- m: mass object in kg

SHM in circular motion

⑥ $x = A\cos\theta$
$= A\cos(\omega t)$
$= A\cos(2\pi f t)$

$x_{max} = A$

→ $PE_{max} = \frac{1}{2}kA^2$

$v = -A\omega\sin\theta$
$= -A\omega\sin(\omega t)$
$= -A\omega\sin(2\pi f t)$

$v_{max} = A\omega$

→ $KE = \frac{1}{2}mA^2\omega^2$

$a = -A\omega^2\cos\theta$
$= -A\omega^2\cos(\omega t)$
$= -A\omega^2\cos(2\pi f t)$

$a_{max} = A\omega^2$

⑦ $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{L}{g}}$

- Period of pendulum
- $2\pi\sqrt{\frac{m}{k}}$: mass on spring
- $2\pi\sqrt{\frac{L}{g}}$: pendulum (L: length of pendulum; g: gravity)

⑧ $\omega = 2\pi f = \sqrt{\frac{k}{m}}$

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CHAPTER 13 : Vibrations and Waves

⑨ $v = f\lambda$

- v — speed of wave
- f — frequency
- λ — crest to crest

⑩ $v = \sqrt{\frac{F}{\mu}}$

- v — speed of wave on string
- F — tension on spring
- μ — linear density

⑪ $\mu = \frac{m}{L}$

- μ — linear density
- m — mass of string (kg)
- L — length of strength (m)

two wave "in phase" → same frequency & amplitude

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CHAPTER 14 : Sound

$V = f\lambda$ * V @ air (20°C) = 343 m/s

Quantity	Infrasonic	sonic (audible)	ultrasonic
example	• earthquake • whale	• human hearing	• dog whistle • medical application
Frequency (f, Hz)	< 20 Hz	20 Hz − 20k Hz	> 20 k Hz
Intensity (I, W/m²)	$< 1 \times 10^{-12}$ W/m²	1×10^{-12} W/m² − 1 W/m²	> 1 W/m²
Intensity level (β, dB)	< 0 dB	0 − 120 dB	> 120 dB

$\Rightarrow I = \frac{E}{At} = \frac{P}{A}$ (E: work done, P: power, A: area)

$\Rightarrow \beta = 10 \log\left(\frac{I}{I_0}\right)$, $I_0 = 1 \times 10^{-12}$

Spherical waves

① $I = \frac{P}{A} = \frac{P}{4\pi r^2}$ (I: sound intensity)

same power source

② $\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$ ⟹

$I_1 = \frac{P}{A_1}$, $P = I_1 A_1$ —①

$I_2 = \frac{P}{A_2}$, $P = I_2 A_2$ —②

① = ② : $I_1 A_1 = I_2 A_2$

$I_1 (4\pi r_1) = I_2 (4\pi r_2)$

$I_1 r_1 = I_2 r_2$

$\frac{I_1}{I_2} = \frac{r_2}{r_1}$

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CHAPTER 14 : Sound

The Doppler Effect

general case	2 cases: approach / away	2 cases: approach / away
observer and source moving	source stationary, observer moving	source moving, observer stationery
$f_0 = f_s \left(\frac{v + v_0}{v - v_s} \right)$ f_0: frequency observer; f_s: frequency source; v: 343 m/s	$f_0 = f_s \left(\frac{v \pm v_0}{v} \right)$ approach : + away : -	$f_0 = f_s \left(\frac{v}{v \mp v_s} \right)$ approach : - away : +

Inteference of sound wave

$(r_2 - r_1) = n\lambda$: constructive

($(r_2 - r_1)$: difference between two waves motion)

$(r_2 - r_1) = (n + \frac{1}{2})\lambda$: destructive

*if $\frac{(r_2 - r_1)}{\lambda}$ is 0, 1, 2, 3 ... → constructive

is $1\frac{1}{2}, 2\frac{1}{2}, 3\frac{1}{2}$ ... → destructive

f_1 = fundemental frequency. (first harmonic)
↳ lowest frequency

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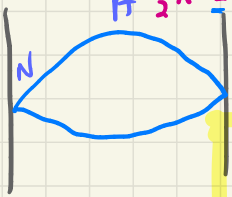
Standing wave on string

$\frac{1}{2}\lambda = L$

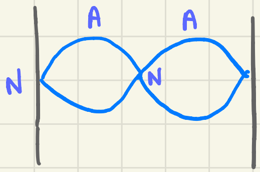
$\lambda_1 = 2L$



$v = f\lambda$
$= f 2L$

$f_1 = \frac{v}{2L}$

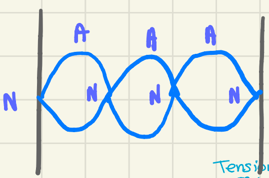
fundemental frequency



$\lambda = L$

$f_2 = \frac{v}{L}$

* $f_2 = 2f_1$



$f_n = nf_1 = \frac{n}{2L}\left(\sqrt{\frac{F}{\mu}}\right)$

Tension of String (F)

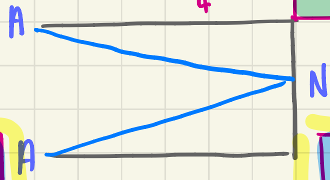
linear density (mass/length) (μ)

$f_1 = \frac{v}{2L}$, $v = \sqrt{\frac{F}{\mu}}$

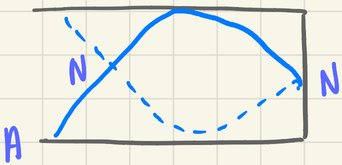
Air column ① (closed at one end)

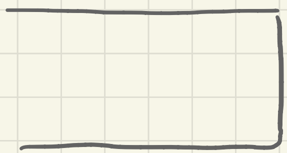
$\frac{1}{4}\lambda = L$

$\lambda = 4L$

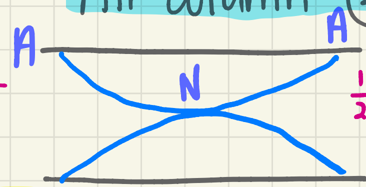


$f_1 = \frac{v}{4L}$





Air column ② (open at both end)

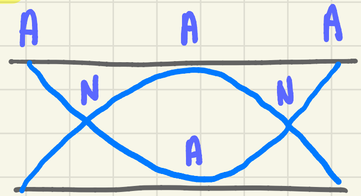


$\frac{1}{2}\lambda = L$

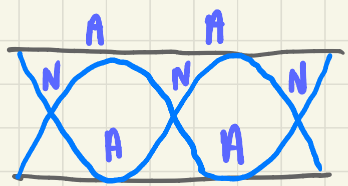
$\lambda_1 = 2L$

$v = f\lambda$
$= f 2L$

$f_1 = \frac{v}{2L}$



$f_n = nf_1$, $n = 1, 3, 5\ldots$



$f_n = nf_1$

ex: $f_4 - f_3 = f_1$ ← *changing between f is f_1