Chapter 6: Kinematics of Rotation of Rigid Bodies

angular displacement, $\theta = \frac{s}{r}$ rad

angular velocity, $\omega = \frac{d\theta}{dt}$ rad s^{-1}

angular acceleration, $\alpha = \frac{d^2\theta}{dt^2} = \frac{d\omega}{dt}$

Relationship between linear and rotational motion

$s = r\theta$

$v = r\omega$

$a = r\alpha$

Rotational motion

$$\boxed{\begin{aligned} \omega &= \omega_0 + \alpha t \\ \theta &= \omega_0 t + \tfrac{1}{2}\alpha t^2 \\ \omega^2 &= \omega_0^2 + 2\alpha\theta \\ \theta &= \tfrac{1}{2}(\omega + \omega_0)t \end{aligned}}$$

$$\boxed{\begin{aligned} v &= u + at \\ v^2 &= u^2 + 2as \\ s &= \tfrac{1}{2}(u+v)t \\ s &= ut + \tfrac{1}{2}at^2 \end{aligned}}$$

Moment of Inertia

- a measure of the object's rotational $\boxed{\text{inertia}}$
  - inertia → resistance to change its angular motion
  - depends on
    - mass
    - axis of rotation
    - shape

$I = \sum \overset{\text{mass}}{m_i} \overset{\text{radius}}{r_i^2}$

Parallel axis theorem

$I_P = I_{cm} + Md^2$

Torque on a rotating body

$\tau = I\alpha = Fr$

Rotational Kinetic Energy and Power

$W = F \cdot s$

$= \frac{\tau}{\cancel{r}}(\cancel{r}\theta)$

$= \tau\theta$

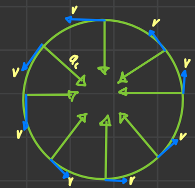
$P = \tau\omega$

$E_{Total} = \underbrace{\tfrac{1}{2}mv^2}_{K_{translational}} + \underbrace{\tfrac{1}{2}I\omega^2}_{K_{rotational}} + mgh$

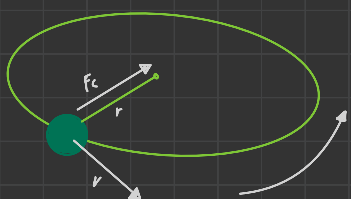
Chapter 7: Circular Motion

Centripetal Acceleration

$$a_c = \frac{v^2}{r} = \frac{(r\omega)^2}{r} = r\omega^2$$



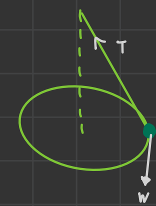
Centripertal force



$$F_c = ma_c = m\frac{v^2}{r} = mr\omega^2$$

Types of circular motion

Conical

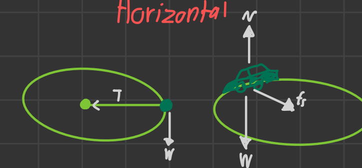


$$F_c = T_x = T\sin\theta = m\frac{v^2}{r}$$

$$\Sigma F_y = 0$$

$$T\cos\theta = W$$

Horizontal

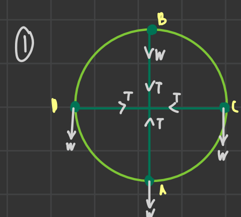


$$F_c = T = ma_c = \frac{mv^2}{r}$$

$$F_c = f_s$$

Vertical

①



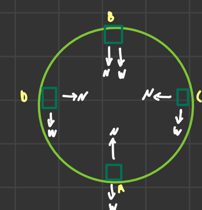
A $F_c = ma_c$
$T - W = ma_c$

B $T + W = ma_c$

C $T = ma_c$

D $T = ma_c$

②



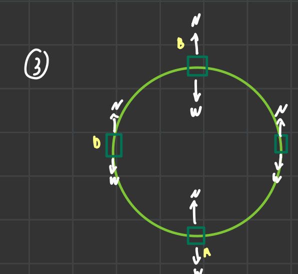
A $N - W = ma_c$

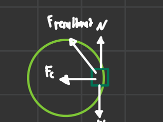
B $N + W = ma_c$

C $N = ma_c$

D $N = ma_c$

③





$$F_{resultant} = \sqrt{F_c^2 + N^2}$$

lowest, A $N - W = ma_c$

highest, B $W - N = ma_c$

Chapter 8: SHM, Mechanical Waves

Period, $T = \frac{2\pi}{\omega} = \frac{1}{f}$

$T_{spring} = 2\pi\sqrt{\frac{m}{k}}$

$T_{simple\ pendulum} = 2\pi\sqrt{\frac{l}{g}}$

$f = \frac{1}{T} = \frac{\omega}{2\pi} = \frac{\text{no. complete cycle}}{\text{time taken}}$

$\omega = \frac{2\pi}{T} = 2\pi f = \frac{v}{r}$

instantenious v	$v = \frac{d}{dt} A\sin$ or $A\cos(\omega t \pm \phi)$
	$v = \omega A\cos$ or $-\omega A\sin(\omega t \pm \phi)$
instantenious a	$a = \frac{d}{dt} v$
v_{max}	$= \omega A$
a_{max}	$= -\omega^2 A$

$y = A\sin(\omega t \pm kx)$

$k = \frac{2\pi}{\lambda}$, $v = f\lambda$

Derivation of stationary wave

$y_1 = A\sin(\omega t + kx)$

$y_2 = A\sin(\omega t - kx)$

left one will always become sin

let $\alpha = \omega t + kx$, $\beta = \omega t - kx$

$y_1 + y_2 = A(\sin\alpha + \sin\beta)$

$= A\left(2\sin\frac{(\alpha+\beta)}{2}\cos\frac{(\alpha-\beta)}{2}\right)$

$y_s = 2A\sin\omega t\cos kx$

Detecting position of nodes/antinodes

nodes $= \frac{n\lambda}{2}$, $n = 0, 1, 2, 3, 4, \ldots$

antinodes: $\frac{m\lambda}{4}$, $m = 1, 3, 5, 7, \ldots$

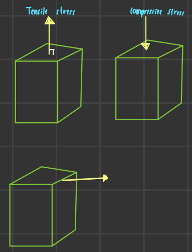
Chapter 9: Deformation of Solids

Behaviour
- elastic – object return to original shape after force is removed
- plastic – object permanently deformed after force is removed

Stress, σ

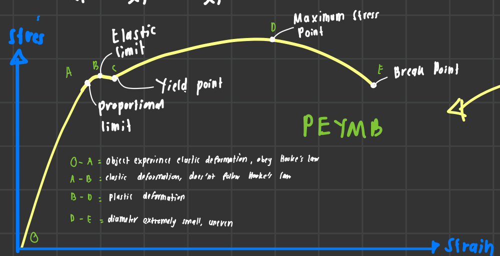
$$\sigma = \frac{F}{A}$$

- **Normal Stress** – Force acting perpendicular to a cross-sectional area
- **Tangential Stress** – Force acting parallel to a cross sectional area

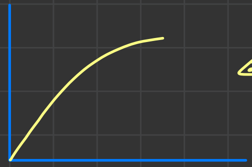


Strain, ε

$$\varepsilon = \frac{e}{l_i} = \frac{\Delta l}{l_i} = \frac{l_f - l_i}{l_i}$$



Ductile
Object experience plastic deformation before break



Brittle
object break as soon as stress increased beyond its elasticity

Young's Modulus, Y

$$Y = \frac{\text{stress}}{\text{strain}} = \frac{\sigma}{\varepsilon} = \frac{F l_i}{A e}$$

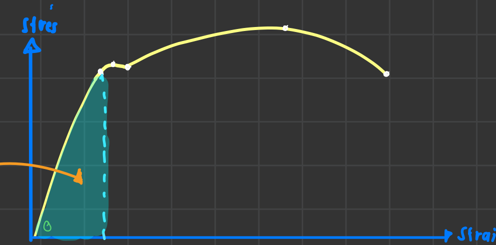
Energy stored / Work done, W

$$W = \frac{1}{2} F e$$

elastic potential energy (U)

Work done per unit volume, W = area under graph

$$W = \frac{1}{2} \times \frac{F}{A} \times \frac{e}{l_i}$$



Chapter 10: Ideal Gas and Thermodynamics

Boyle's Law
- × T constant

$P_1V_1 = P_2V_2$

Charle's Law
- × P constant

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

Pressure's Law
- × V constant

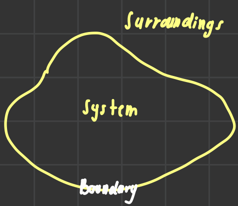
$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Universal gas law

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

ideal gas equation

$PV = nRT$



Work done, $W = P(V_f - V_i)$

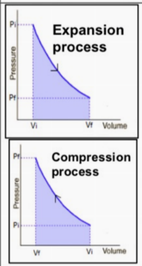
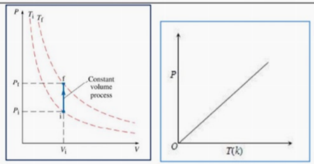
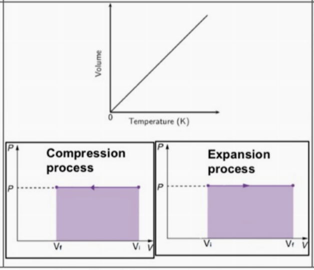
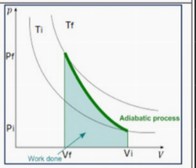
First Law of Thermodynamic

$\Delta U = Q - W$

$\Delta W = +ve$, work done against surrounding - expand

$\Delta W = -ve$, work done on the system - compress

THERMODYNAMICS PROCESS

	ISOTHERMAL	ISOCHORIC/ISOVOLUMETRIC	ISOBARIC	ADIABATIC
IDEAL GAS LAW	Boyle's law (T constant)	Pressure's law (V constant)	Charles' law (P constant)	-
1st LAW	$\Delta U = 0$ $\Delta Q = \Delta W$	$\Delta W = 0$ $\Delta Q = \Delta U$	$\Delta P = 0$ $\Delta Q = \Delta U + \Delta W$	$\Delta Q = 0$ $\Delta W = -\Delta U$
WORK DONE	$W = \mathrm{nRT}\ln\frac{V_f}{V_i}$ $W = \mathrm{nRT}\ln\frac{P_i}{P_f}$	W = 0	$W = P(V_2 - V_1)$	$\Delta W = -\Delta U$
FORMULA	$P_iV_i = P_fV_f$	$\frac{P_i}{T_i} = \frac{P_f}{T_f}$	$\frac{V_i}{T_i} = \frac{V_f}{T_f}$	If the system changes from initial to final, $P_iV_i^\gamma = P_fV_f^\gamma$ $T_iV_i^{\gamma-1} = T_fV_f^{\gamma-1}$ Where γ = molar gas constant (1.41)
GRAPH				

Reminder – Use correct formula for the process described in the question