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Physics 170 Midterm 1: 1 page of notes (Chapters 1-7)

Chapter 1-Systems of Measurement

10^{18}	exa	E	10^{-18}	atto	a	Area	A	L^2
10^{15}	peta	P	10^{-15}	femto	f	Volume	V	L^3
10^{12}	tera	T	10^{-12}	pico	p	Speed	v	L / T
10^{9}	giga	G	10^{-9}	nano	n	Acceleration	a	L / T^2
10^{6} 10^{3}	mega	M	10^{-6}	micro	μ	Force	F	M L / T^2
10^{2}	kilo	k	10^{-3}	milli	m	Pressure (F/A)	p	M / L T^2
10^{1}	hecto	h	10^{-2}	centi	c	Density (M/V)	ρ	M / L^3
	deka	da	10^{-1}	deci	d	Energy	E	M L^2 / T^2
						Power (E/T)	P	M L^2 / T^3

Chapter 2-Motion in one Dimension

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$$

$$v_{av} = \frac{1}{2}(v_0 + v)$$

$$v = v_0 + at$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$x - x_0 = v_0 t + \frac{1}{2}at^2$$

$$x - x_0 = \frac{1}{2}(v_0 + v)t$$

Chapter 3-Motion in Two and Three Dimensions

$$x - x_0 = (v_0 \cos\varphi)t$$

$$y - y_0 = (v_0 \sin\varphi)t - \frac{1}{2}gt^2$$

$$v_y = v_0 \sin\varphi - gt$$

$$v_y^2 = (v_0 \sin\varphi)^2 - 2g(y - y_0)$$

$$y(x) = (\tan\varphi)x - \left(\frac{g}{2v_0^2 \cos^2\varphi}\right)x^2$$

$$R = \frac{v_0^2}{g}\sin 2\varphi$$

Chapter 4-Forces in Nature

Newton's Laws of Motion

1. Every object continues in its state of rest, or of motion in a straight line at constant speed, unless it is compelled to change that state by forces exerted upon it.
2. The acceleration produced by a net force on an object is directly proportional to the magnitude of the net force, is in the same direction as the net force, and is inversely proportional to the mass of the body. F=ma Units: 1 kg/mss = 1 N
3. Whenever one object exerts a force on a second object, the second exerts an equal and opposite force on the first.

Hooke's Law: $F_x = -k\Delta x$ *Acceleration due to gravity:* $g = 9.81\, m/s^2 = 32\, ft/s^2$

Chapter 5-Applications of Newton's Laws

Static Friction: $f_s = \mu_s N$ *Centripetal Force:* $F_c = ma_c = m\left(\frac{v^2}{r}\right)$ *Speed and Period:* $v = \frac{2\pi}{T}r$

Kinetic Friction: $f_k = \mu_k N$

Chapter 6-Work and Energy

Work: $W = Fx\cos\varphi = F \bullet x$ *Power:* $P = \frac{dW}{dt} = \frac{Fdx}{dt} = Fv$ Units: 1 J = 1 N m = 0.738 ft lb; 1 hp = 550 ft lb/s = 746 W

Kinetic Energy: $KE = \frac{1}{2}mv^2$ *Potential Energy:* $PE = mgy$

Potential Energy of a Spring: $U(x) = \frac{1}{2}kx^2$ *Work Energy Theorem:* *W = KE ' - KE = - PE*

Chapter 7-Conservation of Energy

Energy is conserved: $E_i = E_f$ *,where* $E = PE + KE$. *Mass and Energy Relationship:* $E = mc^2$ *,where* $c = 8 \cdot 10^8\, m/s$

$$PE_i + KE_i = PE_f + KE_f$$

Energy Dissipation: $\Delta E_{therm} = f\Delta x$ *Mechanical Energy:* $E_{mech} = -f\Delta x$

Chapter 8-Systems of Particles and Conservation of Momentum

Center of mass: $x_{cm} = \frac{m_1 x_1 + m_2 x_2}{(m_1 + m_2)}$

Momentum: $\vec{p} = m\vec{v}$

Impulse: $I = \int_i^f F dt = \int_i^f \frac{dp}{dt} dt = p_f - p_i = \Delta p$

Time Average of a Force: $F_{av} = \frac{1}{\Delta t}\int_i^f F dt = \frac{I}{\Delta t} \therefore F_{av} = \frac{I}{\Delta p}$ or $\frac{\Delta p}{\Delta t}$

$F\Delta t = \Delta p = mv_f - mv_i = m(v_f - v_i)$

Conservation of Momentum:
1. The total momentum of an isolated system of bodies remains constant.
2. In the absence of an external force, the momentum of a system remains unchanged.

Momentum before = momentum after

$p_1 + p_2 = p_1' + p_2'$

$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$

Coefficient of Restitution: $e = \frac{v_{2f} - v_{1f}}{v_{2i} - v_{1i}}$

Elastic Collision (*e=1*): When objects collide without lasting deformation or the generation of heat.
Inelastic Collisions (*e=0*): Whenever colliding objects become tangled or couple together.

Note: Impact refers to a force (N). Impulse is the product of impact force and time (N s).

Chapter 9-Rotation & Chapter 10-Conservation of Angular Momentum

Cross Product:

$$a \times b = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ a_x & a_y & a_z \\ b_x & b_y & b_z \end{vmatrix} = \begin{vmatrix} a_y & a_z \\ b_y & b_z \end{vmatrix}\hat{i} - \begin{vmatrix} a_x & a_z \\ b_x & b_z \end{vmatrix}\hat{j} + \begin{vmatrix} a_x & a_y \\ b_x & b_y \end{vmatrix}\hat{k} = (a_y b_z - b_y a_z)\hat{i} - (a_x b_z - b_y a_z)\hat{j} + (a_x b_y - b_x a_y)\hat{k}$$

Angular displacement: $\Delta\theta$

Angular velocity: $\omega = \frac{d\theta}{dt}$

Angular acceleration: $\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$

Constant angular: $\omega = \omega_0 + \alpha t$

Acceleration equations: $\theta = \theta_0 + \frac{\omega_0 + \omega}{t}$

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

$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$

Rotation under non-slip conditions: $v_t = R\omega$ $\quad a_t = R\alpha$

Torque: $\tau = r \times F = rF\sin\theta = I\alpha$

Moment of inertia: $I = mr^2$

Angular momentum: $L = r \times p = I\omega = mvr$

Angular impulse: $\tau t = I\omega_f - I\omega_i$

Work: $dW = \tau d\theta$

Kinetic Energy: $K = \frac{1}{2}I\omega^2$

Power: $P = \tau\omega$

Parallel axis theorem: $I = I_{cm} + mh^2$

Chapter 11-Gravity

Newton's law of gravity: $\vec{F}_{1,2} = -\frac{Gm_1 m_2}{r_{1,2}^2}\hat{r}_{1,2}$

Universal gravitational constant: $G = 6.67 \cdot 10^{-11} \frac{\mathrm{N \cdot m^2}}{\mathrm{kg^2}}$

Gravity field of the Earth: $\vec{g} = -\frac{GM_E}{r^2}\hat{r}$

Escape Speed: $V_E = \sqrt{\frac{2GM_E}{R_E}} = \sqrt{2gR_E}$

Velocity of a satellite: $v = \sqrt{\frac{GM}{r}}$

Kepler's third law: $T^2 = \frac{4\pi^2}{GM_s}r^3$

Gravitational potential energy: $U(r) = -\frac{GMm}{r}$

Kepler's three laws of planetary motion:
1. All planets move in elliptical orbits with the sun at one focus.
2. A line joining any planet to the sun sweeps out equal areas in equal times.
3. The square of the period of any planet is proportional to the cube of the planet's mean distance from the sun.

Chapter 12-Static Equilibrium and Elasticity

Conditions for equilibrium:
1. The net external force acting on the body must be zero. $\quad \sum_i \vec{F}_i = 0$
2. The net external torque about any point must be zero. $\quad \sum_i \vec{\tau}_i = 0$

Young's modulus: $Y = \frac{\text{stress}}{\text{strain}} = \frac{F/A}{\Delta L/L}$

Chapter 13-Fluids

Density: $\rho = \frac{m}{v}$

Units: $\mathrm{kg/m^3}$

Pressure: $P = \frac{F}{A}$

Units: $1\mathrm{Pa} = 1\mathrm{N/m^2}$

Bulk modulus: $B = -\frac{\Delta P}{\Delta V/V}$

$1\mathrm{atm} = 101.325\mathrm{kPa} = 14.70\mathrm{lb/in^2}$

$1\mathrm{atm} = 760\mathrm{mmHg} = 760\mathrm{torr} = 29.9\mathrm{inHg}$

Pressure varied with depth: $P = P_0 + \rho gh$

Specific gravity: $\text{sp gr} = \frac{\rho}{\rho_{standard}}$

- Pascal's Principle

A change in the pressure applied to an enclosed fluid is transmitted undiminished to every portion of the fluid and to the walls of the containing vessel.

- Archimedes' Principle

A body wholly or partially immersed in a fluid will be buoyed up by a force equal to the weight of the fluid that it displaces.

- Bernoullis Principle

If the speed of a fluid particle increases as it travels along a streamline, the pressure of the fluid must decrease, and conversely.

Bernoulli's equation: $P + \rho gh + \frac{1}{2}\rho v^2 = \text{constant}$

Continuity equation: $I_v = Av = \text{constant}$

Venturi effect: When the speed of a fluid increases, the pressure drops.

Viscous flow: $\Delta P = P_1 - P_2 = I_v R$

Coefficient of viscosity: $F = \eta\frac{vA}{z}$ $\quad$ Units: $\mathrm{N \cdot s/m^2 = Pa \cdot s = 10 poise}$

Poiseuille's law: $\Delta P = \frac{8\eta L}{\pi r^4} I_v$