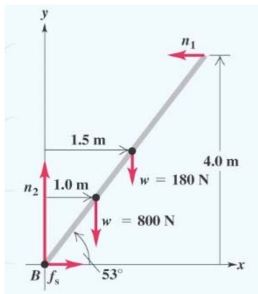
Equation sheet Final Exam, PHY2048

Chapter 11: Equlibrium

Equillibrium of rigid body: $\sum \vec{F} = 0$: and $\sum \vec{\tau} = 0$

FBD for man w/ladder on friction less wall
Torque computed about axis at B but anywhere else is OK.

To solve equilibrium problems begin by using FBD approach. Each force is now applied on extended object. Next write down $\Sigma F = 0$, in x and y, and then write down $\Sigma \tau = 0$, take the axis of rotation for the torques to be anywhere on the object at equilibrium that's convenient. Finally Inspect three equation and solve for unknown(s).



Chapter 12: Fluid Mechanics

Pressure in a fluid at rest (Pascal's Law)

$p_2 = p_2 + \rho g h$, Where the p_2 and p_1 are the pressures at pts 2 and 1, ρ is the density of the fluid, g is the gravitational acceleration and h is the distance in the vertical btw pts 2&1

Density and pressure

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

$$p = \frac{dF_\perp}{dA}$$

Absolute pressure: The total pressure including atmospheric. Gauge pressure: The excess pressure above atmospheric pressure $p_{gauge} = p_{ab} - p_{atm}$

Archimede's principle

$F_B = \rho_f g V$

$\sum \mathbf{F} = 0$

$F_B - mg = 0$

The Buoyant is the upward force excerted by fluid on a body immersed equal to amount of fluid displaced.

Bernoulli's equation

$$p_1 + \rho g y_1 + \tfrac{1}{2}\rho v_1^2 = p_2 + \rho g y_2 + \tfrac{1}{2}\rho v_2^2$$

Chapter 13: Gravitation

Newton's Law of Universal Gravity. ***F*** is the force exerted by objects of mass m_1 and m_2 on one another at a distance r apart. The direction of force is along the line joining the two objects. These force obey Newton's third law and can be considered an action reaction pair.

$$\vec{F} = G_N \frac{m_1 m_2}{r^2}\hat{r}$$

Equations for satellite motion in a circular orbit. Here r is the distance between the satellite and the object being orbited. G_N is Newton's constant and T is the period or time it takes the satellite to go one time around.

$$F_G = m a_{rad} \Rightarrow F_G = m_{Sat}\frac{v^2}{r} \qquad G_N \frac{m_{Earth}}{r} = \left(\frac{2\pi r}{T}\right)^2 \Rightarrow T = \frac{2\pi}{\sqrt{G_N m_{Earth}}} r^{3/2}$$

$$G_N \frac{m_{Sat} m_{Earth}}{r^2} = m_{Sat}\frac{v^2}{r} \Rightarrow G_N \frac{m_{Earth}}{r} = v^2 \qquad G_N = 6.67\times10^{-11}\ N\cdot m^2/kg^2$$

Kepler's Laws

1. Each planet moves in an elliptical orbit with the sun at one of the foci of the ellipse
2. A line from a planet to sun sweeps out equal area in equal times
3. The periods of the planets are proportional to the 3/2 power of the major axis length of their orbit

Potential Energy (U) of a mass a distance r from center of the Earth

$$U_E = -\frac{G_N m_E m}{r}$$

The weigth and gravitational constant g at surface of the earth is

$$w = F_g = \frac{G_N m_E m}{R_E^2}, \text{i} \qquad g = \frac{G_N m_E}{R_E^2}$$

Chapter 14: Periodic Motion

Simple harmonic motion, restorative force proportional to x

$$F_x = -kx, \quad m a_x = -kx, \quad m\frac{d^2x}{dt^2} = -kx \rightarrow \frac{d^2x}{dt^2} = -\frac{k}{m}x$$

Equations of motion for a mass attached to a spring

$$x(t) = A\cos(\omega t); \quad v_x = \frac{dx}{dt} = -\omega A \sin\omega t; \quad a_x = \frac{d^2x}{dt^2} = -\omega^2 A\cos\omega t; \quad \omega = \sqrt{\frac{k}{m}}$$

Total Energy of a mass attached to a spring on a frictionless surface

$$E_T = \frac{1}{2}mv^2 + \frac{1}{2}kx^2, \quad \rightarrow v_x = \sqrt{\frac{k}{m}}\sqrt{A^2 - x^2}$$

$A =$ Amplitude ($\pm$ max displacement from equillibrium)$[m]$

$T =$ Period, time it takes to complete one cycle $[s]$

$f =$ Frequency, how many cycles per sec [Hz or $1/s$]

$\omega =$ Angular frequency which is equal to $2\pi f\ [rad/s]$

$f = \frac{1}{T}$, frequency and period are inverse of each other

Angular simple harmonic motion is

$\omega = \sqrt{\frac{\kappa}{I}}$, where κ is the torsion constant and I is the moment of inertia

The simple pendulum

$\omega = \sqrt{\frac{g}{L}}$, where g is the gravitational acceleration, L is the length of the pendulum

The physical pendulum

$\omega = \sqrt{\frac{mgd}{I}}$, where g is gravitational constant and d is the distance btw center-of-mass and axis, m is the mass and I is the moment of inertia

Chapter 15: Mechanical Waves

The speed of a mechanical wave is:

$v_{wave} = f\lambda$, where f is frequency and λ is the wavelength.

The magnitude of v depends only on the physical properties of the media through which the wave is propagating. Thus for a string of length l the wave speed

$v_{wave} = \sqrt{\frac{F_\perp}{\mu}}$, where μ is the linear mass density or mass per unit length of the string.

Power and Intensity and the Inverse square law

$$I = \frac{P}{4\pi r^2}; \qquad \frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$$

Power in a sinousoidal wave,

$$P(x,t) = \sqrt{\mu F}\,\omega^2 A^2 \sin^2(kx - \omega t)$$

$$P_{max} = \sqrt{\mu F}\,\omega^2 A^2, \quad P_{ave} = \frac{1}{2}\sqrt{\mu F}\,\omega^2 A^2$$

Wave superposition

$$y_{total}(x,t) = y_1(x,t) + y_2(x,t)$$

Standing waves on a string

$$y(x,t) = A_{SW}\sin kx \sin\omega t$$

$$f_n = n\frac{v}{2L} = n f_1 \quad (n = 1,2,3...)$$

$$\lambda_n = \frac{2L}{n} = \frac{1}{n}\lambda_1 \quad (n = 1,2,3...)$$

Equation that describes a mechanical wave

$$y(x,t) = A\cos 2\pi\left(\frac{x}{\lambda} - \frac{t}{T}\right),$$

$$y(x,t) = A\cos(kx - \omega t),$$

with $k \equiv \frac{2\pi}{\lambda}$ and $\omega \equiv \frac{2\pi}{T}$

Velocity and acceleration of any particle on a transverse wave

$$v_y(x,t) = \frac{dx}{dt} = \omega A \sin(kx - \omega t)$$

$$a_y(x,t) = \frac{d^2x}{dt^2} = -\omega^2 A\cos(kx - \omega t)$$

These eq. describe waves propagating to the right with a phase (), amplitude A, angular frequency ω and wave number k