Phys 101.

Lecture 36

April 6, 8. 2011.

Review on selected topics.

1. Vectors.

- What quantities are vectors?

  e.g. Position, displacement, velocity, acceleration.

  force, momentum.

- Addition and subtraction of vetors

  - Tip-to-tail
  - component method.

- components.

  - Why
    a) converting vector sum to algebraic sum.
    b). x- and y- are independent.

  - How. a) to find components
    b) to reconstruct the vetor from components.

- Dot product and work.

$$W = \vec{F} \cdot \vec{\Delta x} \quad (\text{OR} \quad W = \vec{F} \cdot \vec{d})$$

$$W = Fd\cos\theta$$

- Typical mistakes.
  - can't recognize a quantity as a vector.
  - Add/subtract algebraically.
  - forget the direction.

2. Kinematics — description of motion

- graphical relationship.

e.g. $x-t \longrightarrow v-t$
$v-t \longrightarrow a-t.$

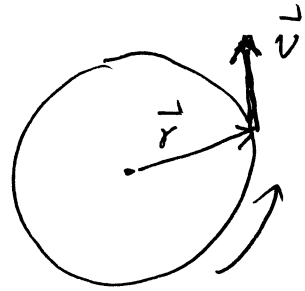
} slope of curve $\rightarrow$
$\leftarrow$ backwards: area under curve.

- projectile motion.
- Linear vs. circular.

$v = r\omega$. (angle - rads)

$a_c = \frac{v^2}{r}$.

$a_t = r \cdot \alpha$.



- Typical mistakes in kinematics:
  - jump to equations without setting up a coordinate system.
  - always assume constant acceleration or even constant velocity.

3. Dynamics

- Free body diagram.
  - Forces { contact forces; field forces (gravity) }
  - Always set up your coordinate system
    (for convenience: make x- or y- along the direction of acceleration)
    ↑ often necessary

- Equations of motion.
  - linear: $\vec{F} = m\vec{a}$
  - Rotation: $\tau = I\alpha$.

  } instantaneous relation.

  Note: $\vec{F}$ is not directly related to $\vec{v}$!

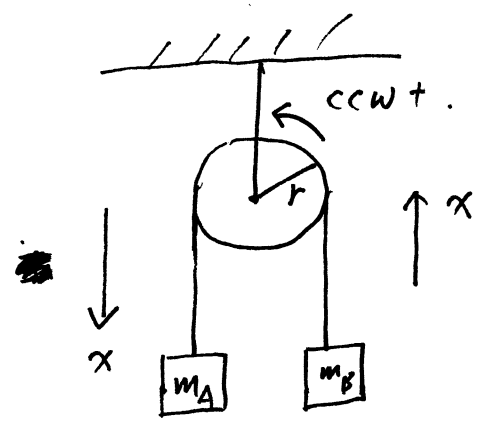
- Typical mistakes:
  - missing forces in FBD.
  - Wrong torques ($\sin\theta$ vs. $\cos\theta$)
  - forget kinematic relation.
    e.g.: $a = r\alpha$.

    e.g. pulley.

e.g. Atwood's machine (lecture 16B)

$a_{Ax} = a_{Bx} = a = r\alpha$.

It's important to choose the coordinate system!



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4. Statics

- static equilibrium: $\vec{F}_{net} = 0$ $(\because \vec{a} = 0)$

  $\tau_{net} = 0$ $(\because \alpha = 0)$

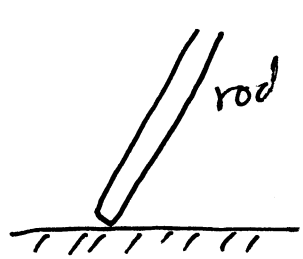
- Axis of rotation for calculating $\tau_{net} = \Sigma \tau_i$

  — Arbitrary, since there is no actual rotation.

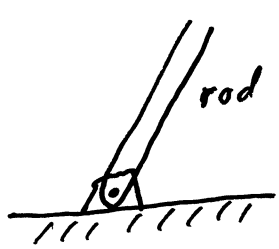
  Then, choose a convient axis. (pivot point)

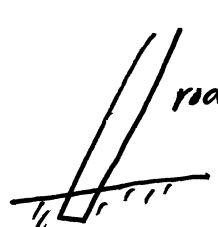
  i.e, unknown forces have zero torques.

- Different kinds of supports:

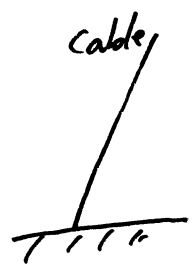


Normal force. and friction





(arbitrary direction)

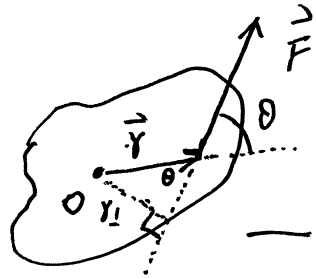


Tention along cable.

- Typical mistakes:

  — Missing $\Sigma \tau = 0$.

  — Wrong assumption about the direction of an unknown force



← force is not along the rod!

  — Torque calculation.

$\tau = Fr \cdot \sin\theta$.

$= F_\perp r$

$= F r_\perp$

just go through the in-class examples, text book examples, assignment. and exams.

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5. Quantities of motion

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

  Impulse-momentum principle: $\vec{J} = \vec{F} \cdot \Delta t = \Delta \vec{p}$

  Time-cumulative effect of the net force ⇝ change in momentum.

- Kinetic energy. $K = \frac{1}{2} m v^2$

  work-energy principle: $W = \vec{F} \cdot \vec{d} = \Delta K$.

  space-cumulative effect of the net force ⇝ change in kinetic energy.

Note: In a many-body system,
internal forces do not contribute to the total momentum.
but they do contribute to the total kinetic energy.

- Angular momentum.

  rigid body: $L = I\omega$.

  moving particle: $L = pr\cdot\sin\theta$

  $= mvr\cdot\sin\theta$.

- Rotational kinetic energy.

  $K_R = \frac{1}{2} I\omega^2$.

- Typical mistakes:

  — Don't know which one to use

  $\Delta\vec{p} = \vec{F}\cdot\Delta t$

  $\Delta K = \vec{F}\cdot\Delta\vec{x}$

  — can't use the idea of $\Delta(\ ) = (\ )_f - (\ )_i$.

  Sometimes we don't have to know the details throughout the course of motion, we only need to deal with the initial and final state.

  can be arbitrary.

  e.g. t_1 and t_2.

6. Conservation Laws.

— Mechanical Energy is conserved if: No non-conservative work.

$$\Delta E = 0$$

— Momentum is conserved: if net external force = 0.

$$\Delta \vec{p} = 0.$$

— Angular momentum is conserved if net external external torque = 0.

— Generalized work-energy principle.

$$W_{nc} = \Delta E$$
$$= \Delta K + \Delta U.$$

Non conservative work on the system = Energy gained by system.

— ~~Energ~~ Kinetic energy is conserved if we have an elastic collission.

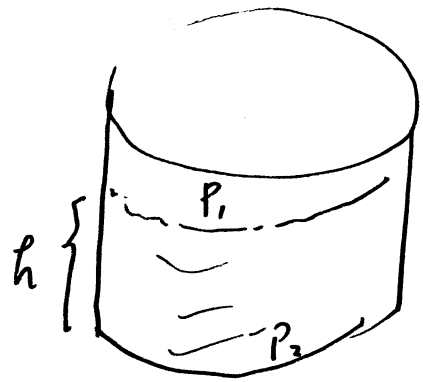
7. Centre of mass. $\vec{x}_c = \frac{\Sigma m_i \vec{x}_i}{M}$

$$M\vec{V}_c = \vec{P}_c = \vec{P}_{Total}.$$

8. Fluids — statics ∴ Apply Newton's law and $\vec{a} = 0$.

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

$$P_2 = P_1 + \rho g h.$$



- Pascal's principle:
  (Hydraulic Lift).

- Buoyancy $B = \rho_\ell \cdot g V$
  ↑ displaced volume.

9. Fluids — Dynamics

- Equation of continuity (mass in = mass out):

$$\rho A V = \text{constant}.$$

When ρ = constant. (such as impressible fluids)

$$A_1 V_1 = A_2 V_2$$

(OR: $AV = \text{constant}$).

- Bernoulli's equation (conservation of energy.
  (no friction, non-viscous flow)

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

why $y \approx$ constant,

$$P + \frac{1}{2}\rho v^2 = \text{const}.$$

(OR: $P_1 + \frac{1}{2}\rho_1 v_1^2 = P_2 + \frac{1}{2}\rho_2 v_2^2$)

~~ρ~~ usually $\rho_1 = \rho_2$

- Poiseuille's law
  flow rate in a round tube (for viscous flow).

$$Q = \frac{\pi R^4 (P_1 - P_2)}{8 \eta \ell}.$$

10. Simple Harmonic Motion.

characteristic equation: $a = -\omega^2 x$.

$(\alpha = -\omega^2 \theta)$.

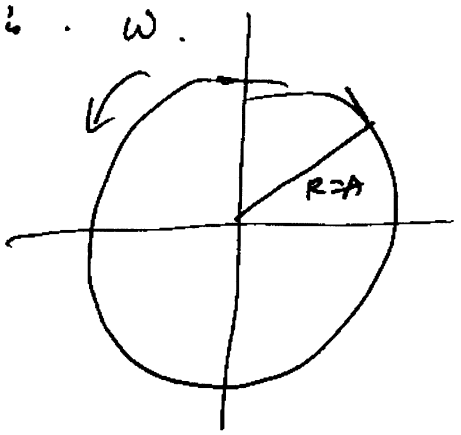
displacement: $x = A \cdot \cos(\omega t + \varphi)$

velocity: $v = -\omega A \cdot \sin(\omega t + \varphi)$

acceleration: $a = -\omega^2 A \cdot \cos(\omega t + \varphi)$

- Reference circle:

SHM can be described by the x-component of a uniform circular motion. ω.



$x_{max} = A$.

$v_{max} = \omega A$

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

- A, ω, φ.

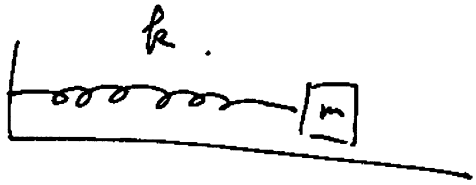
A — amplitude.

ω — angular frequency. $T = \frac{2\pi}{\omega}$, $f = \frac{\omega}{2\pi}$.

φ — initial phase.

~~A, φ, ___ can be determin~~

- Vibrating block.



$F = ma$.

$-kx = ma$.

$a = -\frac{k}{m}x$. $\quad (a = -\omega^2 x)$.

$\omega = \sqrt{\frac{k}{m}}$.

- Simple pendulum.

$\omega = \sqrt{\frac{g}{L}}$

II. Waves, —— propagation of SHM.

$y = A \cdot \cos(kx - \omega t + \phi)$.

$= A \cdot \cos[k(x - vt) + \phi]$.

$k \cdot v = \omega$.

$k = \frac{2\pi}{\lambda}$. $\quad \omega = \frac{2\pi}{T}$. $\quad v$ — speed of wave.

$v = \frac{\lambda}{T} = \lambda f$.

· wave velocity.

$$v = \sqrt{\frac{F_T}{\mu}}$$ — Transverse wave in a cord.

$$v = \sqrt{\frac{E}{\rho}}$$ — For a solid rod.

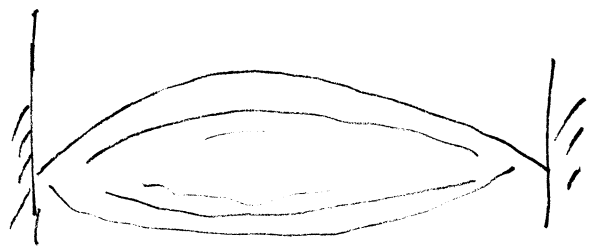
$$v = \sqrt{\frac{B}{\rho}}$$ — for fluids

· Intensity and power of a wave.

$$I = \frac{\bar{P}}{S} = 2\pi^2 v \rho f^2 A^2.$$

$$I \propto \frac{1}{r^2}$$

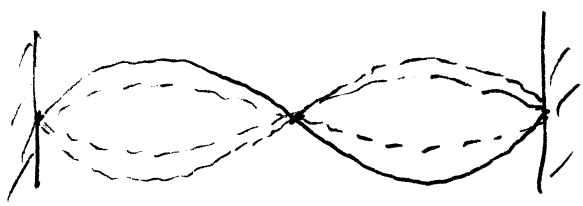
· standing wave



L.

$$L = \frac{\lambda}{2} \cdot n.$$

$$\lambda = \frac{2L}{n}.$$



$$f = \frac{v}{\lambda} = \frac{v}{2L} \cdot n.$$

$n = 1$ — fundamental.

$n = 2$ — 2nd harmonic.

$n = 3$ — 3rd. ...

12. Sound.

- Intensity and Intensity level of sound.

intensity.

$$I = \frac{P}{A}.$$

I — intensity

P — power

A — area.

$P = E/t$.

intensity level:

$$\beta = 10 \log\left(\frac{I}{I_0}\right).$$

in dB.

$I_0 = 1 \times 10^{-12}\ W/m^2$.

(Threshold).

- Doppler effect.

$$f' = f\left(\frac{1 \pm \frac{u_0}{v}}{1 \mp \frac{u_s}{v}}\right)$$

Sign: approaching, f' shifts to higher freq.

receding, f' shifts to lower.

- ~~Superposition principle~~.

~~$y = y_1 + y_2$~~.