Final:
Mon. April 14
8:30 – 11:30 AM.
RM C9001 – A–O
RM C9002 – P–Z

Physics 101

Lecture 36–37

Wed. April 2, 2003.
Friday April 4, 2003

Review on <u>Selected</u> Topics.

1. Vectors.

- What quantities are vectors?

  e.g: position, displacement, velocity, acceleration, momentum

- Addition and subtraction of vectors.
  - Head to tail.
  - component method.

- Components.
  - Why
    a) convert vector sum to algebraic sum.
    b) x- and y- are independent components.
  - How to find components.
  - How to reconstruct the vector from components.

- Dot product and work.

$$W = \vec{F} \cdot \Delta\vec{x}.$$

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

2. Kinematics.

- Definitions.

vector difference!

e.g: $\vec{v}_{av} = \dfrac{\Delta\vec{x}}{\Delta t}$. $\quad \vec{a}_{av} = \dfrac{\Delta\vec{v}}{\Delta t}$.

- Graphical relationship:

e.g: $x \rightarrow v_x \rightarrow a_x$. (slope of curve)

e.g: $a_x \rightarrow v_x \rightarrow x$. area under curve.

- Linear vs. circular.

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

$a_c = \dfrac{v^2}{r}$. $\quad a_t = r \cdot \alpha$.

- Typical Mistakes.
  - — 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.

- Equations of Motion — instantaneous relationship.
  - Linear (can be 3-D): $\vec{F} = m\vec{a}$.
  - Rotation of a rigid body: $\tau = I\alpha$

  Note: There is No instantaneous relation between the net force $\vec{F}$ and the velocity!

- Typical Mistakes { forces missing. wrong torques ($\sin\theta$ vs $\cos\theta$). forget Kinematics relations e.g.: $a = r \cdot \alpha$.

4. statics of a rigid body.

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

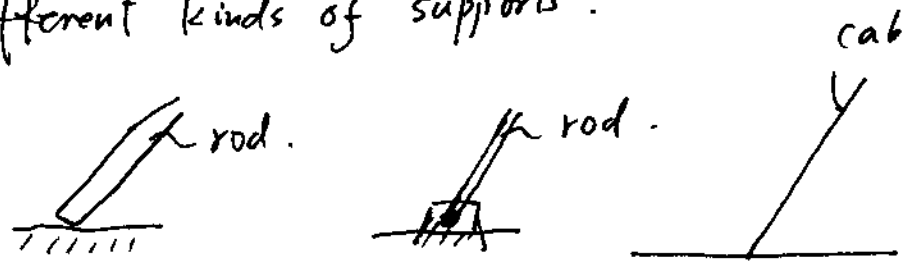
  $\tau_{net} = 0$. $(\because \alpha = 0)$.

- Axis of rotation for calculating $\tau_{net} = \Sigma \tau_i$.
  - arbitrary. since there is no actual rotation.

  · Then, choose a conenient one.

  i.e. unknown forces have zero torques.

- Different kinds of supports.



- Typical mistakes.
  - Can't recognize it's a statics problem.
  - wrong assumption about the direction of an unknown force.
  - Mistakes in torque calculations.

5. Quantities of Motions.

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

$$\Delta\vec{p} = \vec{F}\cdot\Delta t = \overline{\text{Impulse}}. \quad (\text{Impulse-Momentum Thm})$$

Time-cumulative effect of the net force.
$\Rightarrow$ change in momentum.

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

$$\Delta K = \vec{F}\cdot\Delta\vec{x} = \text{Work}. \quad (\text{work-energy Thm})$$

Space-cumulative effect of the net force
$\Rightarrow$ change in Kinetic energy.

Note: for a many-body system.

$$\Delta K_{Total} = \text{Work}_{Total} = \sum \vec{F_i}\cdot\Delta\vec{x_i}.$$

Internal forces contribute to Work_{Total}!
But internal forces don't contribute to $\text{Impulse}_{(Total)}$

- Angular Momentum of a rigid body. $L = I\omega$.

$$\Delta L = \tau\cdot\Delta t.$$

- Rotational Kinetic Energy. $K_R = \frac{1}{2}I\omega^2$.

$$\Delta K_R = \tau\cdot\Delta\theta.$$

- Typical mistakes

— Can't recognize the correspondence
$$\begin{cases} \text{time} \sim \text{momentum} \\ \Delta t \cdot \vec{F} = \Delta \vec{p} \\ \text{distance} \sim \text{Kinetic energy} \\ \Delta \vec{x} \cdot \vec{F} = \Delta K \end{cases}$$

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

i.e., we are only interested in the final and initial states. i.e. the states before and after interaction.

6. Conservative and non-conservative forces.

- Differences: — Whether or not work depends on path.
  — whether or not work can be stored as potential energy.

- Potential energy. U:

$$\Delta U = -W_c. \quad \text{OR}. \quad -\Delta U = W_c.$$

~~The conservative work~~
The work done by a conservative force (W_c) equals the decrease in potential Energy. $(-\Delta U)$

7. Generalized work-energy theorm

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

$(\because \; W_{Total} = \Delta K.$
$W_c + W_{nc} = \Delta K$
$W_{nc} = \Delta K - W_c$
$= \Delta K + \Delta U$

Non-conservative work done on the system equals the increase in Mechanic energy.

8. Conservation Laws:

- when $W_{nc} = 0$, $\Delta E = 0$
  i.e, when there is no non-conservative work, the mechanical energy is conserved.

- when $\vec{F}_{net} = 0$, $\Delta \vec{P} = 0$
  i.e. when the net external force is zero, The momentum is conserved.

- when $\tau = 0$, $\Delta L = 0$.
  i.e. when the total external torque is zero, The angular momentum is conserved.

9. Collisions.

— when $\vec{F}_{net}$ is zero or can be neglected,
Then, $\vec{P} = \text{const}$, (Total momentum is conserved)

— when the collision is elastic.
Then, total kinetic energy is conserved.

— when the collision is completely inelastic,
Then the two objects have the same final velocity. ~~(They get stuck~~
(They stick to each other).

· Typical Mistakes:
— Don't know the conditions for conservation laws.
— unable to solve systems of algebraic equations.

10. Centre of mass. $\vec{x}_c = \dfrac{\sum m_i \vec{x}_i}{M}$, $\vec{v}_c = \dfrac{\sum m_i \vec{v}_i}{M}$.

i.e. $M\vec{v}_c = \sum m_i \vec{v}_i$

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

$\vec{a}_c = \dfrac{\sum m_i \vec{a}_i}{M}$.

11. Friction and Drag.

– Friction : static $f \leq \mu_s \cdot N$.

$f_{max} = \mu_s N$.

Kinetic $f = \mu_k \cdot N$.

– Drag: $f \propto v$ — slow. (without turbulance)

$f \propto v^2$ — fast (with turbulance).

– Terminal velocity of a falling object. $\Big\}\ f(v_T) = mg$.

v = const. eventually

12. Centripetal force. — Required by Newton's 2nd law of Motion.

$$\vec{F}_c = m\vec{a}_c$$

$$F_c = m \cdot \frac{v^2}{R} = mR\omega^2.$$

13. — Topics covered by Midterm #2

— Rotation

— SHM.

— waves

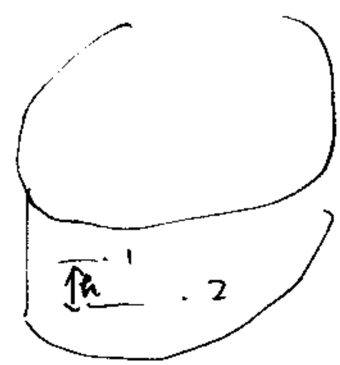
— Sound

(see lecture #26).

14. Fluid statics — Apply Newton's 2nd Law but $\vec{a}=0$.

— Pressure. $P = F/A$.

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



— Pascal's Principle.

(Hydraulic Lift)

— Buoyancy.

$$B = \rho_\ell \cdot g \cdot V$$

V — displaced volume.

15. Fluid dynamics

- Equation of continuity: $\rho A v = \text{const}$. (mass in = mass out.)

  for incompressible fluid (e.g. Liquid).

  $$A v = \text{const}.$$

  OR: $A_1 v_1 = A_2 v_2$.

- Bernoulli's equation. (Work of Pressure = ΔE)
  (Ignore viscosity)

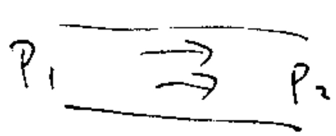
  $$P + \rho g y + \frac{1}{2}\rho v^2 = \text{const}.$$

  When $y = \text{const}$.

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

- Viscous flow:

  Volume flow rate: $Q = \dfrac{(P_1 - P_2) A^2}{8\pi \eta L}$.



  for a cylindrical tube:

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

16. Temperature and Heat.

- Temperature scales.

  Best : Kelvin.

- Thermal expansion

  ~~$\beta = 3\alpha$~~.

  Linear: $\Delta L = \alpha \cdot L_0 \cdot \Delta T$.

  area: $\Delta A = 2\alpha \cdot A_0 \cdot \Delta T$.

  Volume: $\Delta V = 3\alpha \; V_0 \cdot \Delta T$

  OR: $\Delta V = \beta \cdot V_0 \, \Delta T$.

- Conduction.

  Heat flow: $Q = k \cdot A \cdot \left(\frac{\Delta T}{L}\right) t$.

  flow rate: $H = k A \cdot \left(\frac{\Delta T}{L}\right)$.

- Radiation:

  power: $P = e \sigma A T^4$.

  $e = 1$ — black body. (perfect emitter)

17. Idea gas and Kinetic Theory.

$$\frac{PV}{T} = Nk = nR.$$

$$\frac{3}{2}kT = \left(\frac{1}{2}mv^2\right)_{av}.$$

$$v_{rms} = \sqrt{\frac{3kT}{m}}.$$

18. Heat capacity and specific heat:

$$C = \frac{Q}{\Delta T}.$$

$$c = \frac{C}{m} = \frac{Q}{m \cdot \Delta T}.$$

Suggestions:
1. lecture Notes.
2. old Tests.
3. CAPA.
4. Textbook examples.