Topic: 2 Mechanics

Formulae

SUVAT (constant acceleration)

Velocity $V = u + at$ ①

Dis. $S = ut + \frac{1}{2}at^2$ ②

No Time $v^2 = u^2 + 2as$ ③

~~$s = \frac{1}{2}(v+u)t$~~

Average displacement $S = \frac{(v+u)t}{2}$ ④

$a = \frac{\Delta v}{\Delta t} = \frac{v-u}{t}$

$u_x = u\cos\theta$

$u_y = u\sin\theta$

N.D.B. Refer to diagram below: At $s_y = max = height\ h$

① $0 = usin\theta - gt$

② $h = (usin\theta)t - \frac{gt^2}{2}$

③ $0 = u^2\sin^2\theta + 2gh$

④ Range $= 2t(u\cos\theta)$

$F = ma$

$F_F \leq \mu_s R$ $\quad \mu_s > \mu_d$

$F_F = \mu_d R$

$W = mg$

F = resultant force

$W = Fs\cos\theta$

$E_K = \frac{1}{2}mv^2$

$E_p = \frac{1}{2}kx^2$ $\quad F = -kx$

$\Delta E_p = mg\Delta h$ $\quad Power = \frac{E}{t}$

$Power = FV$ $\quad P = Fv\cos\theta$

$Efficiency = \frac{W_{out}}{W_{in}} = \frac{P_{out}}{P_{in}}$

Additional Momentum

$F = \frac{\Delta m}{\Delta t}v$

$F_{ext} = 0$ then $p = CONST$

N.D.B. Important

$p = mv$

$F_{net} = \frac{\Delta p}{\Delta t}$ Newton's 2nd Law

$E_K = \frac{p^2}{2m}$

$Impulse = F\Delta t = \Delta p$

average force

$\Delta E_K + \Delta E_p = 0$ | No drag or friction

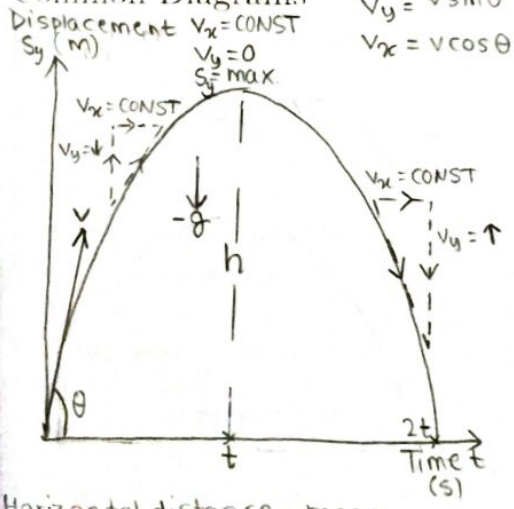
There can be drag or friction though. Then $\Delta E_K + \Delta E_p$ = Heat energy lost from drag or friction.

Required Definitions

13) Efficiency = ratio of output power to input power
14) Linear momentum = refers to the product of an object's mass m & velocity v.
15) Impulse = average force times change in time.

1) Acceleration = change in velocity over time. Instantaneous or Average
2) Velocity = change in displacement over time. Instantaneous or Average
3) Terminal speed = occurs when drag force (air resistance or other fluid resistance) is equal to weight.
4) Force = a push or pull measured in newtons. They are vectors.
5) Tension = always a pull force
6) Friction and normal = surface contact forces. Weight is an action-at-a-distance force.
7) Static friction = when there is no relative motion between surfaces
8) Dynamic Friction = when there is relative motion between surfaces
9) Newton ① Every object remains in its state of motion if no external forces act on it. Inertia is there = a resistance to a change in state of motion
② Force is equal to the change in momentum over unit time. For constant mass, $F = ma$.
③ For every action, there is an equal and opposite reaction.
10) Translational equilibrium - all external forces sum to zero. $\Sigma F = 0$, $a = 0$.
11) Work done = Force times the distance over which it is exerted.
12) Mechanical energy = sum of the total kinetic & potential energy of an object.

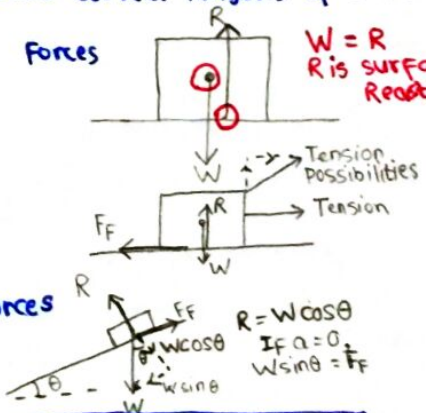
Common Diagrams

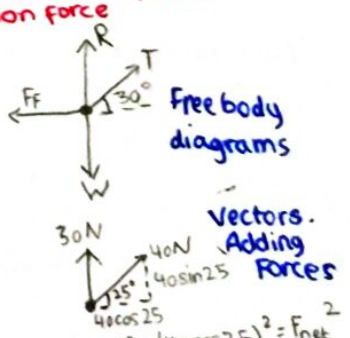


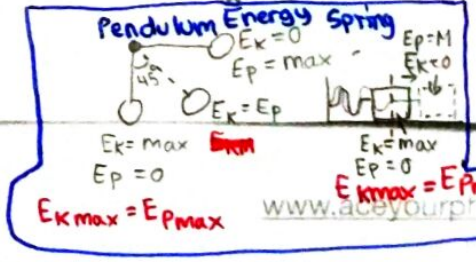
Horizontal distance = range

Projectile Motion

- Show correct lengths of arrow in Free-body diagram

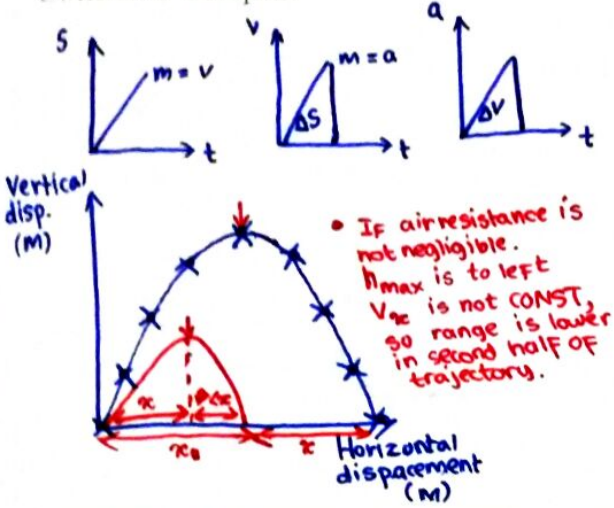




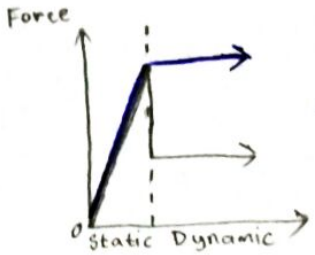


Topic: 2. Mechanics

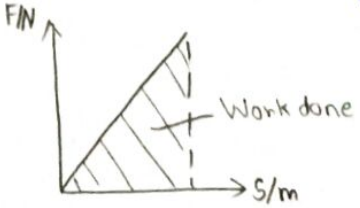
Common Graphs



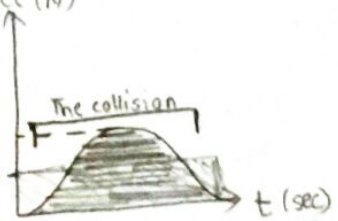
- If air resistance is not negligible. h_{max} is to left V_x is not CONST, so range is lower in second half of trajectory.



- tension
- Friction



$J = F\Delta t = \Delta p = \text{Area}$



like flattening graph

Area = Impulse J

Any of the shapes work but, finding area of rectangle is easier.

Collisions

Elastic, $\Delta E_K = 0$, P = conserved

Inelastic, $\Delta E_K \neq 0$, P = conserved

Perfectly Inelastic, $\Delta E_K \neq 0$, stick together, P = conserved

Explosion

Experiment Summaries

Measuring acceleration of Free Fall (g)

1) Dropping ball from distances & measuring time. $s = ut + \frac{1}{2}at^2$, $u = 0$, $s = \frac{1}{2}at^2$. Find a.

Momentum and Impulse

Study the rocket and pipe one in notes. It is about momentum being conserved. Rocket and air particles or fuel go in opposite direction. Pipe and water go in opposite direction.

$$F = \frac{\Delta m v}{\Delta t}$$

Q) How does an engine (jet) produce thrust?

Ans) The engine sucks in air (at the speed at which it flies), heats it up, and expels it at a greater velocity. The momentum changes since its velocity does, and so an impulse is imparted to it by the engine.

Other Notes Learned From Past Papers

Important topic - Solve problems from slides

- Treat vertical & horizontal components separately - Projectile, forces
- When object goes up, a is negative.
- Horizontal displacement only determines range, not height, time.
- Show correct length of arrows in Free-body diagrams
- ~~Friction F_F and Normal R are always perpendicular to each other.~~ ~~Not in air. On a path~~ yes.
- String and tension problems
- "Closed system" = no work done by external forces
- Remember about direction in momentum. A ball at 40 ms^{-1} when hit back by bat at 50 ms^{-1}, it means $\Delta V = 90\ ms^{-1}$, not $10\ ms^{-1}$.
- Understand "Explain" type theories.
- Conservation of momentum: If net force = 0

$$F = \frac{\Delta p}{\Delta t}$$

$$0 = \Delta p$$

$$\Delta p = 0$$

So, change is 0 and momentum is conserved if no external forces.

If $F_{net} = 0$, P = CONST

- Do 2.4, slides 46-49.

When you have time, use $F = \frac{\Delta p}{\Delta t}$

When not, use $E_{K_F} - E_{K_i} = Fd\cos\theta$

You will have either t or d.

e.g. time of collision or penetration.