**ACE YOUR PHYSICS EXAMS**

**Topic: 2 Mechanics**

### Formulas

**SUVAT (constant acceleration)**

- **Velocity** \( v = u + at \)
- **Distance** \( s = ut + \frac{1}{2}at^2 \)
- **Net Time** \( t = \) need time
- **Average displacement** \( S = \frac{(u + v)t}{2} \)
- \( a = \frac{\Delta v}{\Delta t} = \frac{v - u}{t} \)

**Refer to diagram below:**

- \( v_x = u_x + at \)
- \( v_y = u_y + gt \)
- \( v = \sqrt{v_x^2 + v_y^2} \)
- \( s = s_x + s_y \)
- \( a = \sqrt{a_x^2 + a_y^2} \)

**N-D-B. Important**

- **Impulse** = average force * time

**Additional Momentum**

- \( F = \frac{\Delta p}{\Delta t} \)
- \( F = \frac{\Delta p}{\Delta t} \) Newton's 2nd Law

\( \Delta E_k + \Delta E_p = 0 \) No drag or friction

**Required Definitions**

1. **Efficiency** = ratio of output power to input power
2. **Linear momentum** = product of an object's mass \( m \) and velocity \( v \)
3. **Impulse** = average force * time 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. **Friction and normal** = surface contact forces. **Weight** is an action-at-a-distance force.
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7. **Static friction** = when there is no relative motion between surfaces
8. **Dynamic friction** = when there is relative motion between surfaces
9. **Newton's 1st Law**
- **Every object remains in its state of motion if no external forces act on it.**
- **Force** = net force on an object.
- **For every action, there is an equal and opposite reaction.

10. **Translational equilibrium** = all external forces sum to zero. \( \Sigma F = 0; \Sigma a = 0 \).
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

- **Displacement** \( v_x = \text{CONST} \)
- \( v_y = v \sin \theta \)
- \( v = \sqrt{v_x^2 + v_y^2} \)
- \( s = s_x + s_y \)
- \( \theta = \) need theta

### Show correct lengths of arrow in free-body diagram

- **Forces**
- \( W = R \)
- \( R \) is surface contact force.
- \( W \) is weight force.
- \( F \) is tension force.

### Pendulum Energy Spring

- \( E_k = \frac{1}{2}mv^2 \)
- \( E_p = \frac{1}{2}kx^2 \)
- \( E_{max} = \) energy at max displacement.
- \( E_{min} = \) energy at min displacement.
- \( (z \times 10^3) \) = energy at 10^3 times the displacement.
- \( F_{net} = 0 \)

**Horizontal distance = range**

**Projectile Motion**

\( E_k = E_{p_{max}} \)

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Common Graphs

- If air resistance is not negligible, 
  \( v_{\text{max}} \) is to left.
- \( v_{\text{final}} \) is not \( \text{CONST} \).
- Range is lower in second half of trajectory.

Vertical displacement \((m)\)

\[ s = ut + \frac{1}{2}at^2, \quad u = 0, \quad s = \frac{1}{2}at^2. \]

Work done \([\text{J}][\text{m}]\)

Force \([\text{N}][\text{m}]\)

\[ F = \Delta P = \text{Area} \]

Collisions
- Elastic, \( \Delta E_k = 0 \), \( P \) is conserved.
- Inelastic, \( \Delta E_k \neq 0 \), \( P \) is conserved.
- Perfectly inelastic, \( \Delta E_k = 0 \), stick together, \( P \) is conserved.

Experiment Summaries

Measuring acceleration of Free Fall \((9)\)

1) Dropping ball from distance \( s \), measuring time \( t \): \( s = ut + \frac{1}{2}at^2, \quad u = 0, \quad s = \frac{1}{2}at^2. \) Find \( a \).

2) Momentum and Impulse

Study the rocket and pipe one in notes. It is about momentum being conserved. Rocket and air particles go in opposite direction. Pipe and water go in opposite direction. \( F = \frac{\Delta P}{\Delta t} \).

3) How does an engine produce thrust?

Answer: 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 \( F \) and Normal \( F \) are always perpendicular to each other. \( a \) in air is \( 0 \) on a path.
  - String and tension problems.
  - "Closed System" = no work done by external forces.
  - Remember about direction in momentum. A ball at \( 4 \text{ms}^{-1} \) when hit back by bat at \( 50 \text{ms}^{-1} \), it means \( \Delta V = 46 \text{ms}^{-1} \), not \( 10 \text{ms}^{-1} \).
  - Understand "Explain" type theorism.
  - Conservation of momentum: If net force \( \Delta P = 0 \)
    - If \( F = 0 \), \( P = \text{CONST} \).
    - When you have \( \Delta P \), \( P = \text{CONS} \).
    - You will have either \( t \) or \( d \).
    - e.g., time of collision or penetration.

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