Understanding Work and Kinetic Energy

Introduction to Work and Kinetic Energy

- Work and kinetic energy are fundamental concepts in physics.
- Both are measured in joules (J).
- The relationship between work and kinetic energy is defined by the work-energy theorem.

Work-Energy Theorem

- The work-energy theorem states that the work done by the net force on an object equals the change in its kinetic energy.
- Formula: $W = \Delta KE = KE_{final} - KE_{initial}$
- Where W is work, KE is kinetic energy.

Understanding Work

- Work is defined as the force applied to an object times the displacement in the direction of the force.
- Formula: $W = F \times d$
- Where W is work, F is force, and d is displacement.

Understanding Kinetic Energy

- Kinetic energy is the energy an object possesses due to its motion.
- Formula: $KE = \frac{1}{2} mv^2$
- Where m is mass and v is velocity.

Deriving the Work-Energy Theorem

- Start with a block on a frictionless surface.
- Apply a net force causing displacement.
- Use Newton's second law: $F_{net} = ma$.
- Substitute F in the work formula: $W = ma \times d$.

Kinematics Equation

- Use the kinematics equation: $v_{final}^2 = v_{initial}^2 + 2ad$.
- Rearranging gives: $a \times d = (v_{final}^2 - v_{initial}^2) / 2$.
- Substitute into work formula to relate work and kinetic energy.

Final Kinetic Energy

- Substitute the derived expression into the work formula.
- $W = \frac{1}{2} m(v_{final}^2 - v_{initial}^2)$.
- This shows how work done changes kinetic energy.

Example Problem: Calculating Work

- Consider a 10 kg block with a force of 90 N applied over a displacement of 20 m.
- Calculate work using $W = F \times d$.
- $W = 90\ N \times 20\ m = 1800\ J$.

Calculating Change in Kinetic Energy

- Initial speed of the block is 4 m/s.
- Calculate initial kinetic energy: $KE_{initial} = \frac{1}{2} mv_{initial}^2 = \frac{1}{2} \times 10\ kg \times (4\ m/s)^2 = 80\ J$.
- Final speed needs to be calculated after applying force.

Finding Final Speed

- Use F = ma to find acceleration: a = F/m = 90 N / 10 kg = 9 m/s^2.
- Use kinematics to find final speed after 20 m: $v_{final}^2 = v_{initial}^2 + 2ad$.
- Solve for v_final.

Final Kinetic Energy Calculation

- Calculate final kinetic energy after applying force.
- Use $KE_{final} = \frac{1}{2} m v_{final}^2$.
- Find the change in kinetic energy: $\Delta KE = KE_{final} - KE_{initial}$.

Using Work-Energy Theorem

- Work done can also be calculated using the change in kinetic energy.
- W = KE_final - KE_initial.
- Confirm that both methods yield the same result.

Second Example Problem

- Consider a 5 kg block with a force of 40 N applied for 8 seconds.
- Calculate acceleration: $a = F/m = 40\ N / 5\ kg = 8\ m/s^2$.
- Determine final velocity after 8 seconds.

Calculating Displacement

- Use the formula: $d = v_{initial} \times t + \frac{1}{2} at^2$.
- Since $v_{initial}$ is 0, $d = \frac{1}{2} \times a \times t^2$.
- Calculate displacement during the time force is applied.

Work Done by the Force

- Calculate work done using $W = F \times d$.
- Substitute the values of force and displacement to find work.

Final Kinetic Energy for Second Example

- Calculate final kinetic energy using $KE = \frac{1}{2} mv^2$.
- Confirm that work done equals the change in kinetic energy.

Summary of Key Concepts

- Work and kinetic energy are interconnected through the work-energy theorem.
- Work can be calculated using force and displacement or through changes in kinetic energy.
- Understanding these concepts is crucial for solving physics problems.

Questions for Discussion

- How does friction affect the work done on an object?
- Can work be negative? If so, how does that affect kinetic energy?
- How would you apply these concepts in real-world scenarios?