16: Work, Power, and Energy

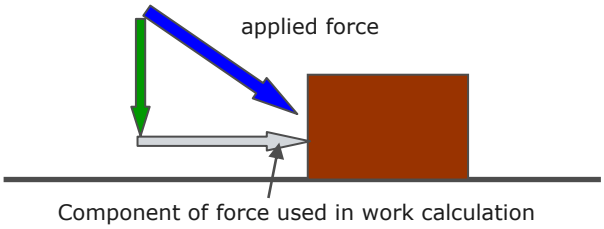
Key Physics Terms

- **Force**: Any influence that tends to accelerate an object; a push or a pull measured in Newtons. Force is a vector quantity.
- **Distance:** The quantity that describes the position of an object. Distance is a scalar quantity.
- **Displacement:** The quantity that describes the change in location of an object which includes its direction of motion. Displacement is a vector quantity.
- **Acceleration:** Rate at which an object's velocity changes with time; this change may in speed, direction, or both.
- **Vector:** A quantity that represents magnitude (size) and direction. It is usually represented with an arrow to indicate the appropriate direction. They may or may not be drawn to scale.
- **Component:** Parts into which a vector can be separated and that act in different directions from the vector.
- **Work:** Product of force on an object and the distance through which the object is moved.
- **Power:** Work done per unit of time.
- **Energy:** The ability to do work.
- **Base level:** An arbitrary reference point from which distances are measured.
- **Kinetic Energy:** The energy an object has due to it motion.
- **Gravitational Potential Energy:** The energy an object has due to its position above some base level.
- **Work Energy Theorem:** The work done is equal to the change in energy.
- **Conservation of Energy:** energy is not created or destroyed, just transformed from one type to another.

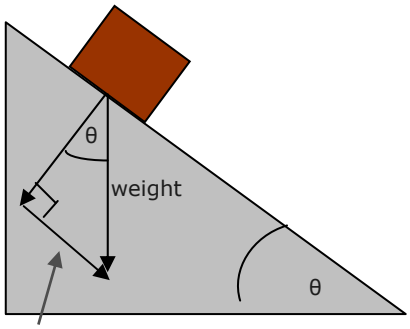
Key Formulas

- $W = F\,d = ma\,d$
- $W = F\,d\cos\theta$
- $P = W/t$
- $a = \Delta v/\Delta t$
- $\cos\theta$ = adjacent / hypotenuse
- $KE = \frac{1}{2}\,mv^2$
- $PE = mgh$
- $PE_{spring} = 1/2\,kx^2$
- $F_{spring} = -kx$

Typical Vector Diagrams



Component of force used in work calculation since this is the direction of motion.



Component of force used in work calculation since this is the direction of motion.

Key Concepts

- Work is done only when a force acts in the direction of motion of an object
- If the force is perpendicular to the direction of motion, then no work is done.
- Power is the ratio of work done per time.
- Any moving object possesses kinetic energy.
- When an object is lifted above some arbitrary base level position, its gravitational potential energy is increased.
- Energy may appear in different forms, but it is always conserved.
- The total amount of energy before and after some interaction is constant.
- Work and energy are interchangeable.

Key Units

- Force: Newtons, N
- Displacement: meters, m
- Work: Joules, J
- 1 Joule = 1 N m = 1 kg m^2/s^2
- Power : Watts, W
- 1 Watt = 1 J/s

Key Conventions

- If the force and displacement are in the same direction, the work is positive, +.
- If the force and displacement are in opposite directions, the work is negative, -.

Work and Power Problem Solving Tips

- These tips will make it easier to solve work and power physics problems.
- Thoroughly read the entire problem.
- Draw a diagram if needed.
- Identify all given information.
- Identify the quantity to be found.
- Select appropriate formula(s) that incorporate what you know and what you want to find.
- Convert units if needed. Use units throughout your calculations.
- Do any mathematical calculations carefully.
- When using trig functions, be sure your calculator is the correct mode (degrees or radians).
- When calculating work, be sure to use only the component of force in the direction of motion.
- For conservation of energy problems, try to identify the various types of energy in the situation. If possible, equate the energies to help solve for any unknowns.
- Check to see if your answer seems reasonable. If not, go back and look for errors.

Energy Specific Problem Solving Tips

- For conservation of energy problems, try to identify the various types of energy in the situation. If possible, equate the energies to help solve for any unknowns.
- Often quantities like mass cancel out. This means you don't need to know these to calculate another variable.
- When assigning the base level, the ground or floor in the problem is usually a good choice.
- If energy seems to be missing or disappear, consider where the energy may have been converted. Heat, friction, and air resistance are common possibilities.

How to Use This Cheat Sheet: These are the keys related this topic. Try to read through it carefully twice then recite it out on a blank sheet of paper. Review it again before the exams.