8.7: Work and Kinetic Energy (Summary)

Key Terms

average power	work done in a time interval divided by the time interval
kinetic energy	energy of motion, one-half an object's mass times the square of its speed
net work	work done by all the forces acting on an object
power	(or instantaneous power) rate of doing work
work	done when a force acts on something that undergoes a displacement from one position to another
work done by a force	integral, from the initial position to the final position, of the dot product of the force and the infinitesimal displacement along the path over which the force acts
work-energy theorem	net work done on a particle is equal to the change in its kinetic energy

Key Equations

Work done by a force over an infinitesimal displacement	$dW = \vec{F} \cdot d\vec{r} = \lvert\vec{F}\rvert \lvert d\vec{r}\rvert \cos\theta$	(8.7.1)
Work done by a force acting along a path from A to B	$W_{AB} = \int_{path\ AB} \vec{F} \cdot d\vec{r}$	(8.7.2)
Work done by a constant force of kinetic friction	$W_{fr} = -f_k \lvert l_{AB}\rvert$	(8.7.3)
Work done going from A to B by Earth's gravity, near its surface	$W_{grav,\ AB} = -mg(y_B - y_A)$	(8.7.4)
Work done going from A to B by one-dimensional spring force	$W_{spring,\ AB} = \left(\frac{1}{2}k\right)(x_B^2 - x_A^2)$	(8.7.5)
Kinetic energy of a non-relativistic particle	$K = \frac{1}{2}mv^2 = \frac{p^2}{2m}$	(8.7.6)
Work-energy theorem	$W_{net} = K_B - K_A$	(8.7.7)
Power as rate of doing work	$P = \frac{dW}{dt}$	(8.7.8)
Power as the dot product of force and velocity	$P = \vec{F} \cdot \vec{v}$	(8.7.9)

Summary

7.1 Work

- The infinitesimal increment of work done by a force, acting over an infinitesimal displacement, is the dot product of the force and the displacement.
- The work done by a force, acting over a finite path, is the integral of the infinitesimal increments of work done along the path.
- The work done against a force is the negative of the work done by the force.

- The work done by a normal or frictional contact force must be determined in each particular case.
- The work done by the force of gravity, on an object near the surface of Earth, depends only on the weight of the object and the difference in height through which it moved.
- The work done by a spring force, acting from an initial position to a final position, depends only on the spring constant and the squares of those positions.

7.2 Kinetic Energy

- The kinetic energy of a particle is the product of one-half its mass and the square of its speed, for non-relativistic speeds.
- The kinetic energy of a system is the sum of the kinetic energies of all the particles in the system.
- Kinetic energy is relative to a frame of reference, is always positive, and is sometimes given special names for different types of motion.

7.3 Work-Energy Theorem

- Because the net force on a particle is equal to its mass times the derivative of its velocity, the integral for the net work done on the particle is equal to the change in the particle's kinetic energy. This is the work-energy theorem.
- You can use the work-energy theorem to find certain properties of a system, without having to solve the differential equation for Newton's second law.

7.4 Power

- Power is the rate of doing work; that is, the derivative of work with respect to time.
- Alternatively, the work done, during a time interval, is the integral of the power supplied over the time interval.
- The power delivered by a force, acting on a moving particle, is the dot product of the force and the particle's velocity

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