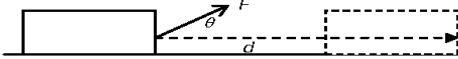


AP Physics 4: Linear Momentum and Energy

Name _____

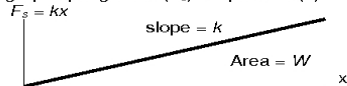
A. Momentum and Energy formulas

- impulse changes object's momentum: $F\Delta t = m\Delta v = \Delta p$
- quantity of motion (vector quantity): $p = mv$ (kg·m/s)
- work changes object's energy: $W = F_{\parallel}d$ (J)
 - measured in joules (1 J = 1 N·m)
 - Only component of F parallel to d does work



- $F_{\parallel} = F\cos\theta \therefore W = (F\cos\theta)d$
- include sign $\therefore W > 0$ when $F \rightarrow d \rightarrow$
- $F \uparrow \downarrow$ when $d \rightarrow$ (orbit)

- variable force—stretching a spring
 - graph spring force (F_s) vs. position (x)



- $F_s = kx \therefore$ slope = $\Delta F_s / \Delta x = k$
- $W = F_s x \therefore$ area = $\frac{1}{2}x(kx) = \frac{1}{2}kx^2 = W$

- power is the rate work is done: $P = W/t$ (W)
 - measured in watts (1 W = 1 J/s)
 - $P = W/t = F(d/t) = Fv_{av}$ (v is average)
 - graphing
 - $P = W/t \therefore$ slope of W vs. t graph
 - $P = Fv_{av} \therefore$ area under F vs. v graph
 - kilowatt-hour, 1KWh = 3.6×10^6 J

- mechanical energy
 - work-energy theorem: work done to an object increases mechanical energy; work done by an object decreases mechanical energy
 - scalar quantity, like work
 - kinetic energy—energy of motion
 - positive only
 - $K = \frac{1}{2}mv^2 = p^2/2m$

Steps	Algebra
start with assume $K_0 = 0 \therefore v_0 = 0$ solve for ad	$v^2 = v_0^2 + 2ad$ $v^2 = 2ad$ $ad = \frac{1}{2}v^2$
start with substitute ma for F substitute $\frac{1}{2}v^2$ for ad rearrange	$K = W = Fd$ $K = (ma)d = m(ad)$ $K = m(\frac{1}{2}v^2)$ $K = \frac{1}{2}mv^2$
start with square both sides divide both sides by $2m$ substitute K for $\frac{1}{2}mv^2$	$mv = p$ $m^2v^2 = p^2$ $m^2v^2/2m = p^2/2m$ $K = p^2/2m$

- potential energy—energy of relative position
 - gravitational potential energy
 - based on arbitrary zero (usually closest or farthest apart)
 - $U_g = mgh$ (near the Earth's surface)

Steps	Algebra
start with substitute mg for F substitute h for d	$U_g = W = Fd$ $U_g = (mg)d$ $U_g = mgh$

- $U_g = -GMm/r$ (orbiting system)
 - $G = 6.67 \times 10^{-11}$ N·m²/kg²
 - r = distance from center to center
 - $U_g = 0$ when r is $\infty \therefore U_g < 0$ for all values of r because positive work is needed reach $U_g = 0$

- spring (elastic) potential energy, $U_s = \frac{1}{2}kx^2$
 - $U_s = W$ to stretch the spring
 - see work by a variable force above