PhyzExamples: Energy

Physical Quantities • Symbols • Units • Brief Definitions

Work • *W* • joule: J • A form of mechanical energy transfer.
Potential Energy • *PE* • joule: J • Energy of position.
Kinetic Energy • *KE* • joule: J • Energy of motion. Notice the spelling: NOT "kenetic."
Power • *P* • watt: W • Rate at which energy is transferred or transformed, often the rate at which work is done.

Equations in Symbols and Words

$W = F \cdot d$ • *work = force · distance* (THE FINE PRINT: Work is a scalar quantity that can be positive, negative, or zero. Since work is not a vector, the sign does not indicate direction; it indicates whether energy is being added or removed. If **F** and **d** are in the same direction or at an acute angle to each other, *W* is positive; if **F** and **d** are opposite to each other or at an obtuse angle, *W* is negative; if **F** and **d** are perpendicular, no work is done.)
$PE = mgh$ • *gravitational potential energy = mass · gravitational acceleration · height*
$KE = {}^1/_2 mv^2$ • *kinetic energy = ½ · mass · speed squared*
$P = W/t$ • *power = work / time*

$P = F \cdot v$ • *power = force · speed* (THE FINE PRINT: Power is a scalar quantity that can be positive, negative, or zero. Since power is not a vector, the sign does not indicate direction; it indicates whether energy is being added or removed. If **F** and **v** have components parallel to each other, *P* is positive; if **F** and **v** have components antiparallel, *P* is negative; if **F** and **v** are perpendicular, no power is developed.)

Smooth Operations Examples

1. How much work is done if an 8 N force is used to move a book 3 m across a table?

1. F = 8 N d = 3 m W = ?
W = F · d
W = 8N · 3m
W = 24 J

2. How much force is exerted on an egg with 90 J of kinetic energy to stop it if it comes to rest (in a suspended bedsheet) across a distance of 1.5 m?

2. W = ΔKE = 90 J d = 1.5 m F = ?
W = F · d
F = W/d
F = 90 J / 1.5 m
F=60 N (≈ 12 lb!)

3. How high must a 3 kg AP Physics book be held to have 76 J of gravitational potential energy?

3. m = 3 kg PE = 76 J h =?
PE = mgh
h = PE/mg
h = 76 J / 3 kg · 9.8 m/s2
h = 2.6m

4. A 5 kg rock on Mars is dropped from a height of 3 m on a nail and does 57 J of work. What is the gravitational acceleration on Mars?

4. m = 5 kg h = 3 m PE = W = 57 J g = ?
PE = mgh
g = PE/mh
g = 57 J / 5 kg · 3 m
g = 3.8 m/s²

5. What is the kinetic energy of a 16 g bullet moving at 250 m/s?

5. $m = 16\ g = 0.016\ kg$ $v = 250\ m/s$ $KE = ?$
$KE = 1/2\ mv^2$
$KE = (1/2)(0.016\ kg)(250\ m/s)^2$
$\underline{KE = 500\ J}$

6. How fast is a 500 kg car moving if 100 kJ of work went into accelerating it?

6. $m = 500\ kg$ $KE = W = 100{,}000\ J$ $v = ?$
$KE = 1/2mv^2$
$v = \sqrt{(2 \cdot KE/m)}$
$v = \sqrt{(2 \cdot 100{,}000\ J / 500\ kg)}$
$\underline{v = 20\ m/s}$ (≈ 45 mph)

7. How long would it take a 1 kW motor to do 1 MJ of work?

7. $P = 1000\ W$ $W = 1{,}000{,}000\ J$ $t = ?$
$P = W/t$
$t = W/P$
$t = 1{,}000{,}000\ J / 1000\ W$
$\underline{t = 1000\ s}$

8. How much power must be delivered by a car engine to keep a car moving at 25 m/s while encountering a drag force of 10,000 N?

8. $v = 25\ m/s$ $F = 10{,}000\ N$
$P = F \cdot v$
$P = 10{,}000\ N \cdot 25\ m/s$
$\underline{P = 250{,}000\ W}$ (≈ 330 hp)