Name: ______________________________ Phys 12

4.2 Conservation of Energy, Power, and Efficiency

Equations from Physics 11:	Conservation of Energy equations:
Power (watts) = $\frac{Work}{Time} = \frac{\Delta Energy}{Time}$	$\Delta E_p = -\Delta E_k$ OR $E_{k_{initial}} + E_{p_{initial}} = E_{k_{final}} + E_{p_{final}}$ OR
Efficiency (%) = $\frac{Work_{out}}{Work_{in}}$ or $\frac{Power_{out}}{Power_{in}} \times 100\%$	$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f$

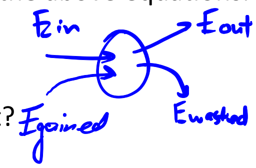
Last year, we discuss how energy cannot be **created** or **destroyed**, meaning the **total energy change** is **zero.** The following equations can be summarized below, describing the **conservation of energy**.

$$\Delta E_p + \Delta E_k = 0 \quad \text{OR} \quad \Delta E_p = -\Delta E_k \quad \text{OR}$$
$$E_{k_{initial}} + E_{p_{initial}} = E_{k_{final}} + E_{p_{final}} \quad \text{OR} \quad \frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f$$

In ideal situations, our system does not lose energy, but sometimes it does in the form of heat or thermal energy.

Although the total energy change is still zero, we need to account for the energy that is lost in the above equations.

$$E_{k_{initial}} + E_{p_{initial}} = E_{k_{final}} + E_{p_{final}} + E_{lost}$$



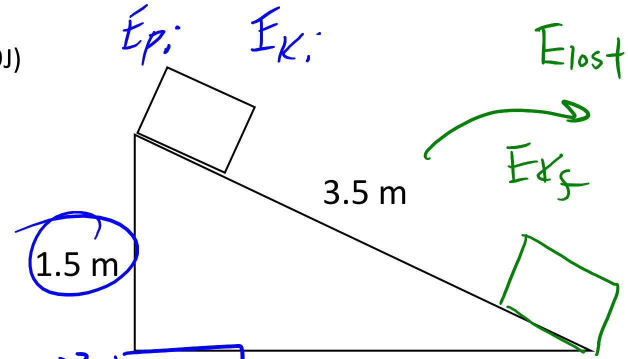
Extension how would you write the above equation if energy is added (E_{gained}) instead of lost?

$E_{gained} + E_{k_i} + E_{p_i} = E_{k_f} + E_{p_f} \; (+ E_{lost})$

Ex. 1: A 5.0 kg block of wood was sliding down the ramp with a velocity of 6.0m/s at the top. At the bottom of the ramp, it was traveling at 7.5m/s.

a) How much thermal energy was generated due to friction? (ANS: 22.9J) → E_{lost} J

b) Determine the force of friction (ANS: 6.5N)



a) $E_{p_i} + E_{k_i} = E_{k_f} + \cancel{E_{p_f}} + E_{lost}$ (0)

$mgh_i + \frac{1}{2}mv_i^2 = \cancel{\frac{1}{2}mv_f^2} + E_{lost}$

$-\frac{1}{2}mv_f^2 \qquad \cancel{-\frac{1}{2}mv_f^2}$

$E_{lost} = mgh_i + \frac{1}{2}mv_i^2 - \frac{1}{2}mv_f^2$

$= 5.0(9.8)1.5 + \frac{1}{2}(5.0)(6.0)^2 - \frac{1}{2}(5.0)(7.5)^2 = \boxed{22.9\text{J}}$

b) $E_{lost} \rightarrow$ work done by friction

$E_{lost} = \frac{W}{d} = \frac{F_f \times \cancel{d}}{\cancel{d}}$

$F_f = \frac{W}{d} = \frac{22.8\ldots\text{J}}{3.5\text{m}} = \boxed{6.5\text{ N}}$

Name: ______________________________ $P = \frac{W}{t} = \frac{Fd}{t} = F \cdot v$ Phys 12

Power

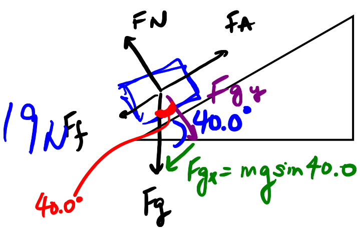
Definition: the rate of work being done, measured in Joules/sec (J/s) or Watts (W)

Power (Watts) = $\frac{Work}{Time} = \frac{\Delta Energy}{Time}$

Another way to calculate **power** is $\boxed{P = F \times v}$ *NOTE! only when v is constant AND F is constant

Where F is force (N)
and v is velocity (m/s)

Ex. 2: A student pushes 14.0 kg of their physics homework up a 40.0° ramp at a constant velocity of 3.20 m/s. The friction force is 26.0 N. How much power must the student exert? (ANS: 365W)



$F_A = F_f + F_{gx} = 26.0N + mg\sin 40.0$
$= 26 + 14(9.8)\sin 40.0 = 114.19N$

$P = F \cdot v = 114.19..(3.20m/s) = \boxed{365W}$

Efficiency

When our system loses energy when doing work, it's not efficient as we would like it to be. To express this, we use:

Efficiency (%) = $\frac{Work_{out}}{Work_{in}}$ or $\frac{Power_{out}}{Power_{in}} \times 100\%$

Work/Power input is how much work/power was **used.**

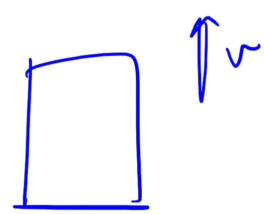
Work/Power output is how much useful work/power was **done.**

During the process, energy being lost means that INPUT $\geq$ OUTPUT.

Ex. 3: A 1960kg elevator was provided with 129kW of electric power to move the elevator up 6.0m moving at a constant speed of 3.8m/s.
a) How much energy was lost? (ANS: 74kJ)
b) What is the efficiency in the elevator motors? (ANS: 42%)

P_{in} $P_{in} \rightarrow P_{out}$, P_{lost}

E_p E_K



$P_{in} = P_{out} + P_{lost}$

$P_{out} = \frac{\Delta E}{t} = \frac{E_p + E_K}{t} = \frac{mg\Delta h + \frac{1}{2}mv^2}{t} =$

$= \frac{1960(9.8)(6.0) + \frac{1}{2}(1960)3.8^2}{6.0/3.8}$

$= 129\ 399.2W$

$\frac{d}{t} = v$

$t = \frac{d}{v}$

$P_{lost} = P_{in} - P_{out} = 129\ 000W - 129\ 399.2W =$

$P_{lost} = \frac{W}{t} \Rightarrow W = P_{lost}t$
$= \boxed{74kJ}$

HW: Worksheet 4.2 #4, 6, 8, 10, 11, 12, 13, 15, 16, 18