Name: ______________

Learning Intention

- Understanding the definitions of work, energy, and power
- Learn how to calculate the gravitational potential energy of an object.

Definitions and Formulas

1. Work, power, and energy give us a new framework to use to solve all sorts of physics problems.
2. Work was originally defined by Gaspard-Gustave Coriolis as a weight lifted through a height.
3. The definition of work we will use is

$$W = F_{\parallel} d$$

W : work in Joules (J)
F : force parallel to displacement (N)
d : displacement of the object (m)

   a. Work is a (scalar / ~~vector~~).
   b. If you push on an object and it does not move, you have done zero Joules of work on the object. However, your muscles get tired because they do work on themselves.

4. The net work is the sum of all the work done on and by an object.
5. In physics, energy is the ability to do work.
6. The Theory of Conservation of Energy states that energy cannot be created or destroyed, but can only change form.
   a. This is often written as:

$$\Sigma E_i = \Sigma E_f$$

The sum of the initial energies is equal to the sum of the final energies

See over →

7. In physics, power is the rate of doing __work__. It is defined by the equation:

$$P = \frac{W}{t}$$

P: power in Watts (W)

W: work in Joules (J)

t: time in seconds (s)

8. Coriolis was interested in raising heavy loads out of mines. He wanted to know how much energy it would take to lift a load from the bottom of a mine up to the surface. We will assume that the load has a mass of m kilograms and the mine has a depth of h meters.

   a. Draw a free body diagram of the mass, as it is moving upwards at a constant velocity. What is the upwards force?

$$\vec{F}_{net} = m\vec{a} = 0$$
$$\vec{F}_t + \vec{F}_g = 0$$
$$F_t - F_g = 0$$
$$F_t = F_g = mg$$

   b. How much work is done on the mass as it is raised by a height h?

$$W = F_{\parallel} d = F_t \cdot h = mgh$$

   c. When the mass is lifted, __work__ is performed, and the __energy__ is transformed into __gravitational__ __potential__ __energy__.

9. Near the surface of the Earth, gravitational potential energy is calculated as

$$E_p = mgh$$

E_p: potential energy in Joules (J)

m: mass (kg)

g: gravity (N/kg)

h: height (m)

1. a. $W_a = F_a \parallel d = 56\ N \times 13\ m = 728\ N \cdot m$

$\boxed{W_a = 730\ J}$

b. $W_f = F_f \parallel d = 32\ N \times 13\ m = 416\ N \cdot m$

$\boxed{W_f = -420\ J}$

c. $W_{net} = W_a + W_f = 728\ J + -416\ J = 312\ J$

$\boxed{W_{net} = 310\ J}$

2. $W = F \parallel d = 220\ N \times 0\ m$

$\boxed{W = 0\ J}$

3. a. $E_p = mgh = 1{,}200\ kg \times 9.81\ N/kg \times 382\ m = 4{,}496{,}904\ N \cdot m = 4.5 \times 10^6\ N \cdot m$

$\boxed{E_p = 4.5\ MJ}$

b. $P = \frac{W}{t} = \frac{4{,}496{,}904\ J}{37\ s} = 121{,}538\ J/s$

$\boxed{P = 120\ kW}$

4. a. $W = P \cdot t = 60\ W \times 3.15 \times 10^7\ s = 1.89 \times 10^9\ J$

$\boxed{W = 1.9\ GJ = 1.9 \times 10^9\ J}$

b. $W = P \cdot t = 13\ W \times 3.15 \times 10^7\ s = 4.095 \times 10^8\ J$

$\boxed{W = 410\ MJ = 4.1 \times 10^8\ J}$

5. $1\ \cancel{kW} \cdot \cancel{hr} \times \frac{1000\ W}{\cancel{kW}} \times \frac{3600\ s}{\cancel{hr}} = 3.6 \times 10^6\ J$

$\boxed{E = 3.6 \times 10^6\ J = 3.6\ MJ}$

6. $E_p = mgh = 266\ kg \times 9.81\ N/kg \times 1.83\ m = 4775.3\ J$

$\boxed{E_p = 4,780\ J}$

7. $h = \frac{E_p}{mg} = \frac{4800\ J}{52\ kg \times 9.81\ N/kg} = 9.4096\ m$

$\boxed{h = 9.4m}$

8. a. $E = 75\ \cancel{cal} \times \frac{4184\ J}{\cancel{cal}} = 313,800\ J$

$h = \frac{E_p}{mg} = \frac{313,800\ J}{90\ kg \times 9.81\ N/kg} = 355.4\ m > 315\ m$

$\boxed{Yes}$

b. $\boxed{h = 360\ m}$

9. $P = \frac{W}{t} = \frac{mgh}{t} = \frac{35\ kg \times 9.81\ N/kg \times 315m}{(9\ min \times 60 \frac{s}{min} + 55s)} = 181.8\ W$

$\boxed{P = 180\ W}$