Work, Energy & Power

Useful equations:

$$P = \frac{\Delta E}{\Delta t} \qquad\qquad W = \Delta E \qquad\qquad \begin{aligned} E_g &= mgh \\ E_k &= \frac{mv^2}{2} \end{aligned}$$

Examples

1. Calculate the amount of work a crane does on a crate of mass 2500 kg lifting it from 2m above the ground to 25 m?

2. If the crane in question 1 lifts the crate in 15s, how much power did it generate?

3. A 1500 kg car accelerated from 5 m/s to 20 m/s in 6 seconds. How much work did the engine do and how much power did it deliver?

Efficiency

Useful equations:

$$\% \, efficiency = \frac{E_{useful \, output}}{E_{input}} \times 100\%$$

Examples

1. A washing machine is 30% efficient. 2000 J of electrical energy are input into the machine. Calculate the amount useful output energy?

2. Calculate the efficiency of a crane that uses 5.10 x 10^5 J of energy to lift 1000 kg a vertical height of 32.0 m?

3. The power rating on an electrical device says that it is running at 900 W of power. If the device is run for 10 minutes and outputs 4.8x10^5 J of energy, calculate the efficiency of the device.

Interesting Conversion:

1 horse-power (hp.) = 750 W

Questions

Power Problems

1. If a hair-straightener does 2,500 J of work to heat the air every 2 seconds, calculate the power of the hair-straightener.

2. Mr. Braun shovels his driveway in 30 minutes using a shovel. If he does 30,000 J of work calculate his power.

3. Calculate how long it would take a 1.2 kW (1kW = 1000W) electric motor to do 5.4×10^3 J or work.

4. An 1100 kg car is attached to a lift that can generate 1210 W of power. If it takes 2 minutes to lift the car calculate the vertical distance through which it was raised.

5. An engine supplies 25,000 W of power to a 1500 kg car accelerating it from 3 m/s to 30 m/s. Calculate the time required for this acceleration. Also, how many horse-power is this engine?

6. A 1700 kg Ferrari has a 500 hp engine. If the car accelerates from rest for 4 seconds at full power calculate how fast it will be going at the end of the acceleration.

7. Abby pushes a 900 kg car from rest to a speed of 4 m/s in a time of 3 minutes. Calculate the power that she exerts and convert this to horse-power units.

Efficiency Problems

1. A particular light bulb is known to be 7.5% efficient.
   a) How much light energy would actually be provided by a 100 W light bulb in one minute of operation?
   b) What would be the effective "light power" from this 100 W bulb?

2. A mix-martial arts punch can transfer 35.0 J of total energy to kinetic energy. If this transfer is only 30% efficient, what maximum velocity can the 70.0 kg target ever reach?

3. A water pump is run by an electric motor with a power rating of 750 W. It is used to pump water from a reservoir up to a height of 37.0 m and into a water tower at a rate of 1.5 kg of water per second.
   a) What is the useful energy output, $E_{useful\ output}$?
   b) What is the efficiency of the water pump?