



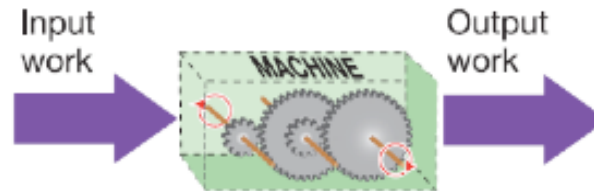
## **Chapter Seven: Work and Energy**

- **7.1 Force, Work, and Machines**
- **7.2 Energy and the Conservation of Energy**
- **7.3 Efficiency and Power**



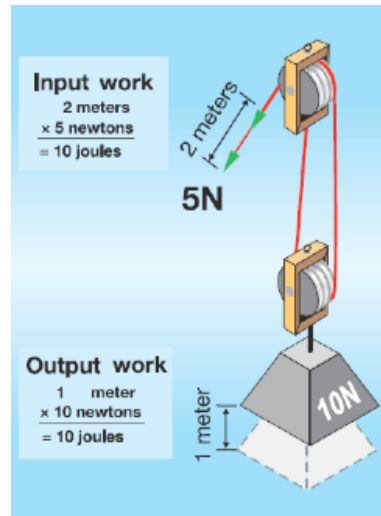
## 7.3 Efficiency and Power

- Every process that is done by machines can be simplified in terms of work:
  1. **Work input:** the work or energy supplied to the process (or machine).
  2. **Work output:** the work or energy that comes out of the process (or machine).





## 7.3 Efficiency and Power

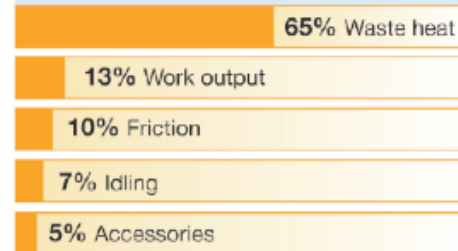


- A rope and pulley machine illustrates a rule that is true for all processes that transform energy.
- The total energy or work output can never be greater than the total energy or work input.

## 7.3 Efficiency

- 65% of the energy in gasoline is converted to heat.
- As far as moving the car goes, this heat energy is “lost”.
- The energy doesn’t vanish, it just does not appear as useful output work.

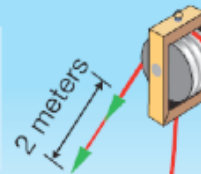
Energy Use in a Typical Car



## Work Input and Output

### Input work

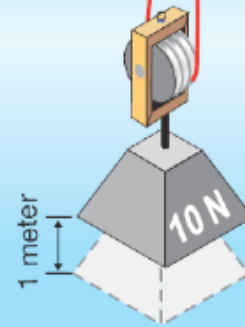
$$\begin{array}{r} 2 \text{ meters} \\ \times 5 \text{ newtons} \\ \hline = 10 \text{ joules} \end{array}$$



5 N

### Output work

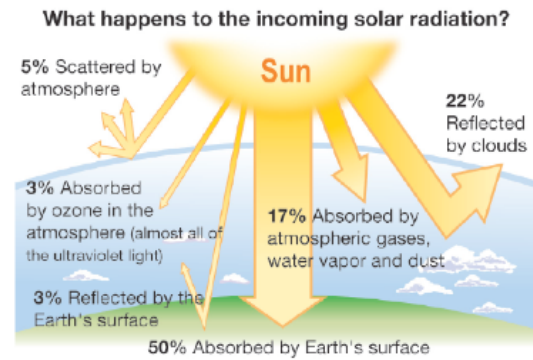
$$\begin{array}{r} 1 \text{ meter} \\ \times 10 \text{ newtons} \\ \hline = 10 \text{ joules} \end{array}$$





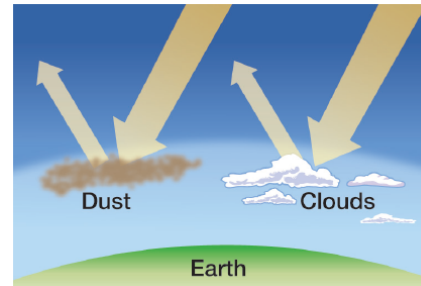
## 7.3 Efficiency in natural systems

- Energy drives all the processes in nature.
- Earth absorbs this solar energy with an average efficiency of





## 7.3 Efficiency in natural systems



- In any system, all of the energy goes somewhere.
- The energy that is not absorbed by Earth is reflected back into space.
- Another way to say this is that energy is conserved.

## 7.3 Power

- The rate at which work is done is called **power**.
- It makes a difference how fast you do work.

### *POWER*

$$\text{Power (watts)} \text{ --- } P = \frac{W}{t}$$

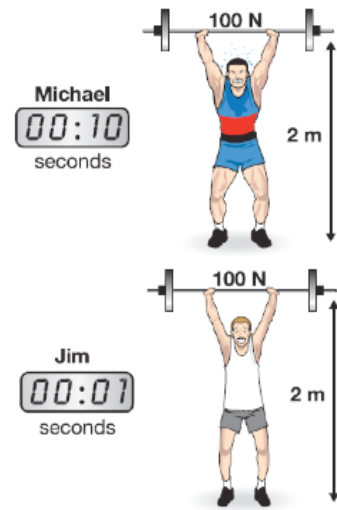
*W* — Work (joules)  
*t* — Time (seconds)



## 7.3 Power

- Power is calculated in watts.
- One watt (W) is equal to 1 joule of work per second.
- James Watt, a Scottish engineer, invented the steam engine.
- James Watt explained power as the number of horses his engine could replace.
- One horsepower still equals 746 watts.

## 7.3 Power



- Michael and Jim do the same amount of work.
- Jim's power is greater because he gets the work done in less time.



ENERGY ►► CONNECTION

## A Matter of Survival

- In 2005, the U.S. Defense Advanced Research Projects Agency (DARPA) launched its VHESC program.
- The goal of the program is to develop solar cells that would operate at or above 50 percent efficiency.

