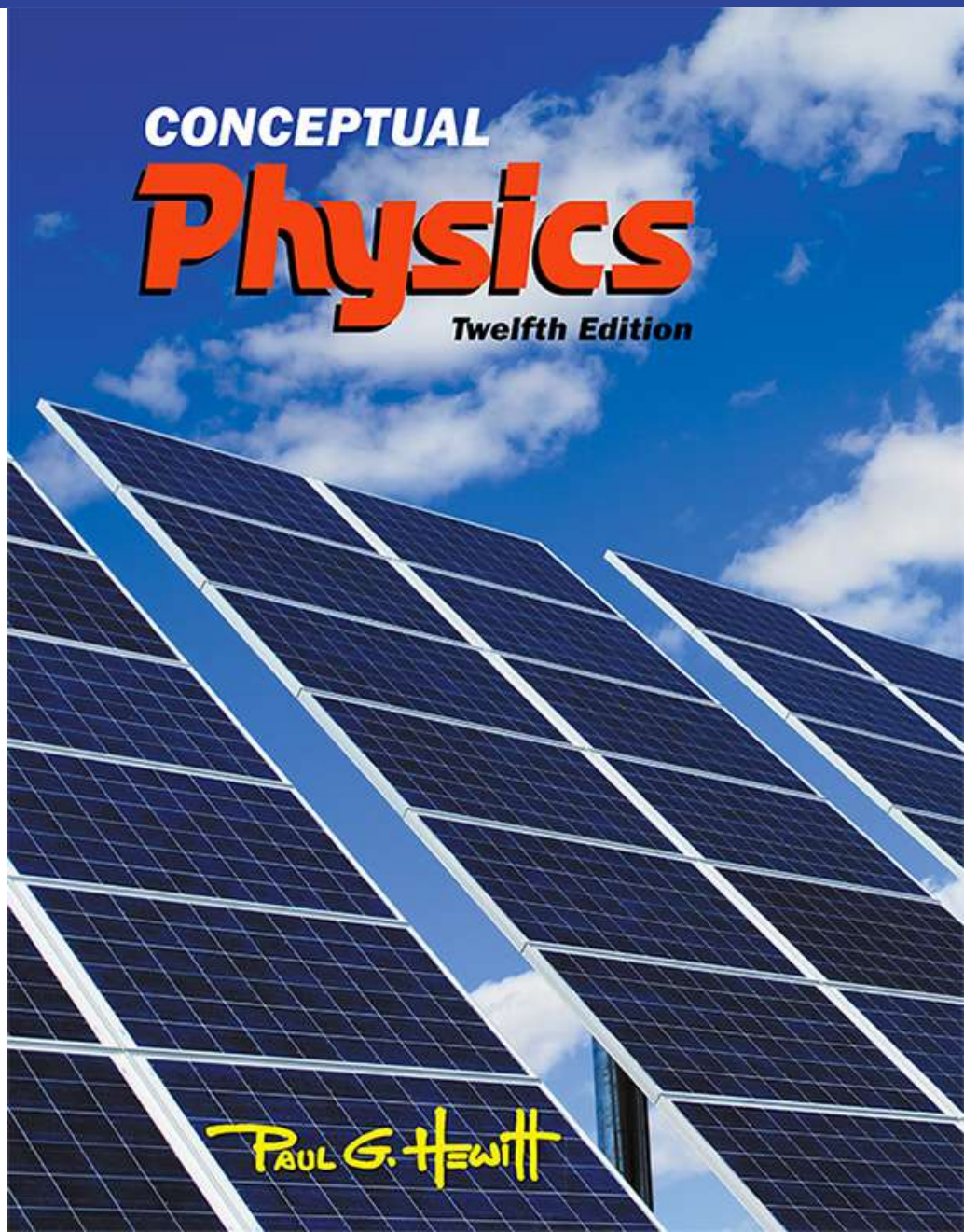
Lecture Outline

Chapter 7: Energy

- Machines
- Efficiency



Machines

- What is a Machine?
  - Device for multiplying forces or changing the direction of forces
  - Cannot create energy but can transform energy from one form to another, or transfer energy from one location to another
  - Cannot multiply work or energy

Machines, Continued

- Principle of a machine:

  Conservation of energy concept:

$$\text{Work input} = \text{work output}$$

$$\text{Input force x input distance} = \text{output force x output distance}$$

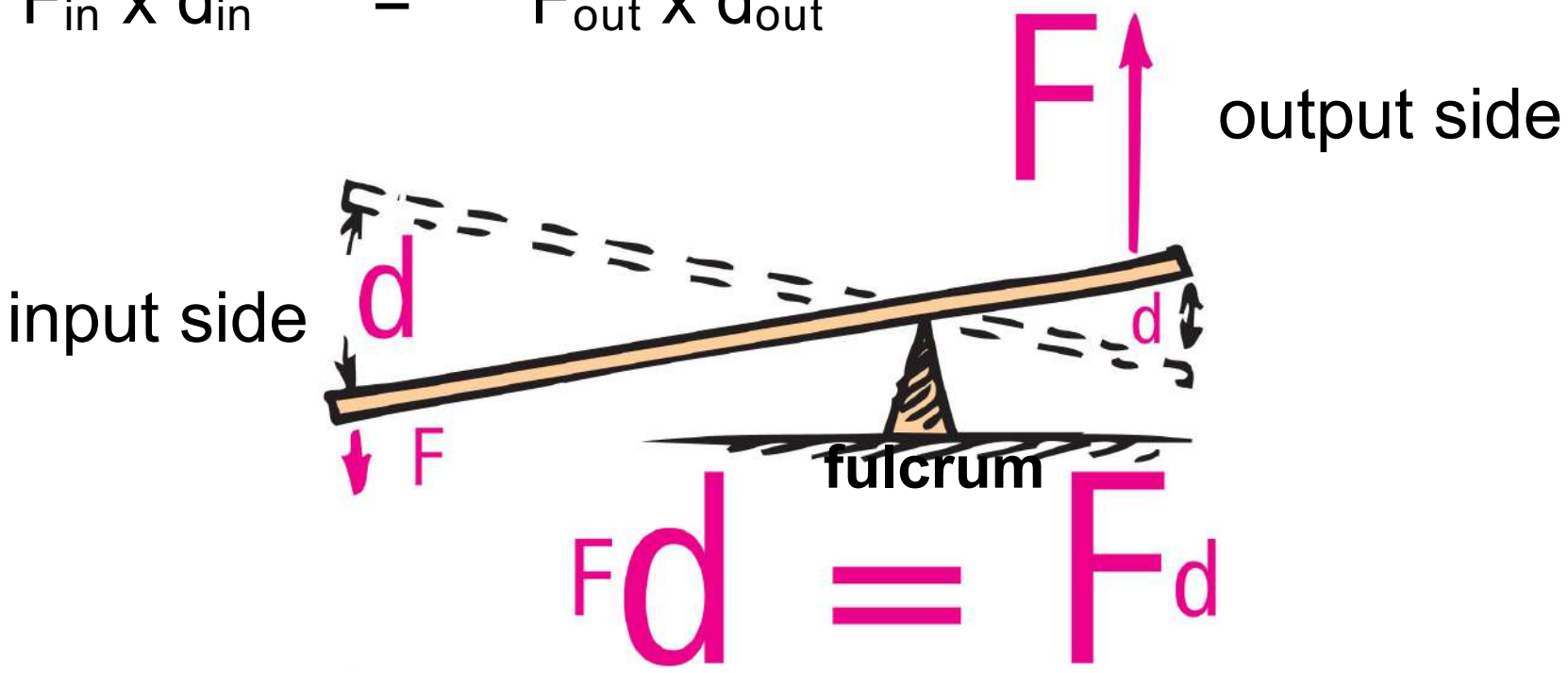
$$(\text{Force x distance})_{\text{input}} = (\text{force x distance})_{\text{output}}$$

$$F_{in} \times d_{in} = F_{out} \times d_{out}$$

Simplest machine: the lever

- rotates on a point of support called the **fulcrum**
- allows small force over a large distance and large force over a short distance

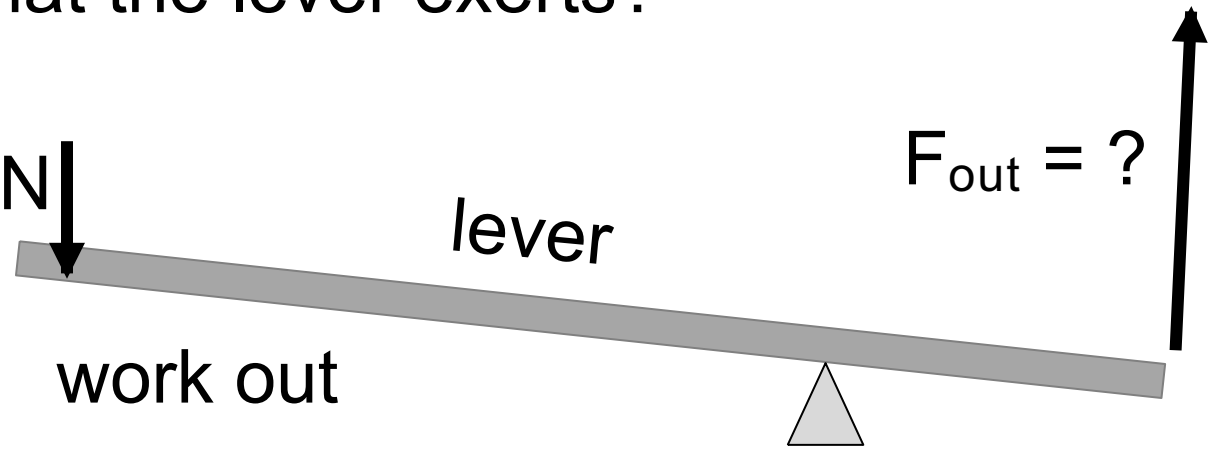
$F_{in} \times d_{in} = F_{out} \times d_{out}$



The force is multiplied.

Ex. levers multiply forces

Nellie Newton applies a force of 50 N to the end of a lever, which is moved a certain distance d. If the other end of the lever moves one-third as far, what is the force that the lever exerts?



work in = work out

$F_{in} \times d_{in} = F_{out} \times d_{out}$

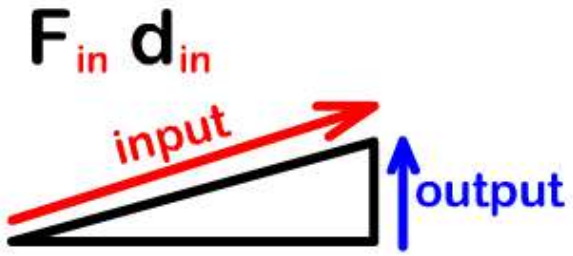
$(50\ N) \times d = F_{out} \times \frac{d}{3}$

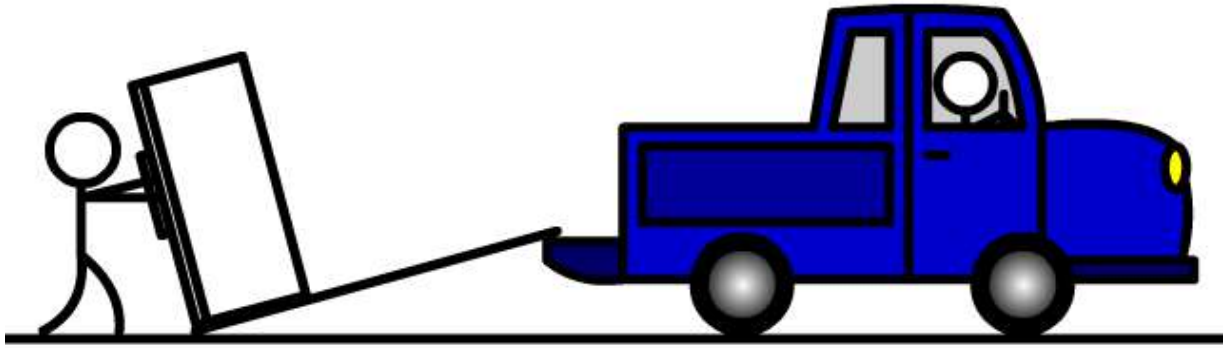
$50\ N = F_{out} \times \frac{1}{3}$

$F_{out} = 3(50\ N)$

$F_{out} = 150\ N$

An incline (ramp) is also a simple machine:

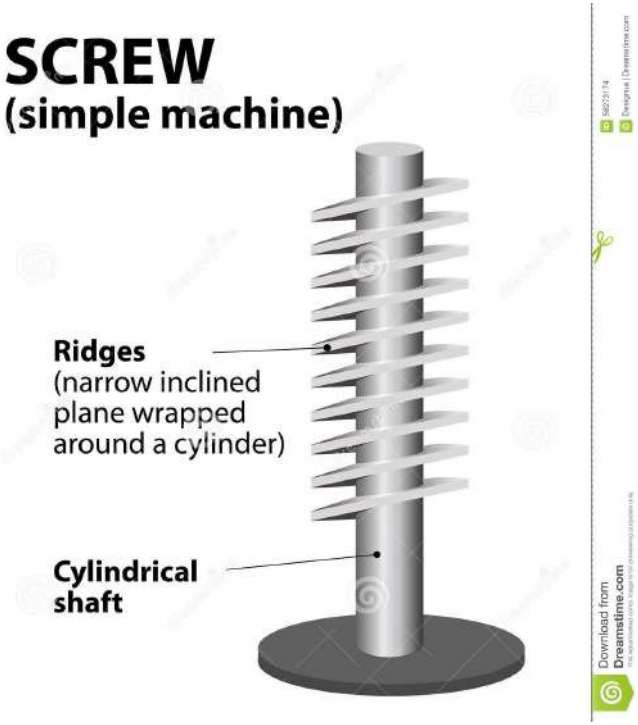


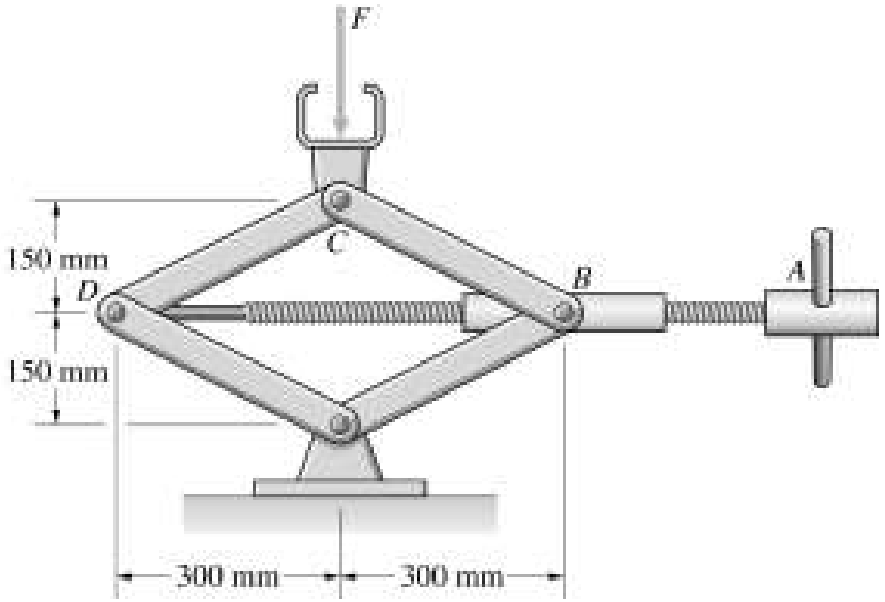


work in = work out

smaller F_{in} x longer d_{in} = greater F_{out} x shorter d_{out}

A screw is an incline wrapped around a cylinder:



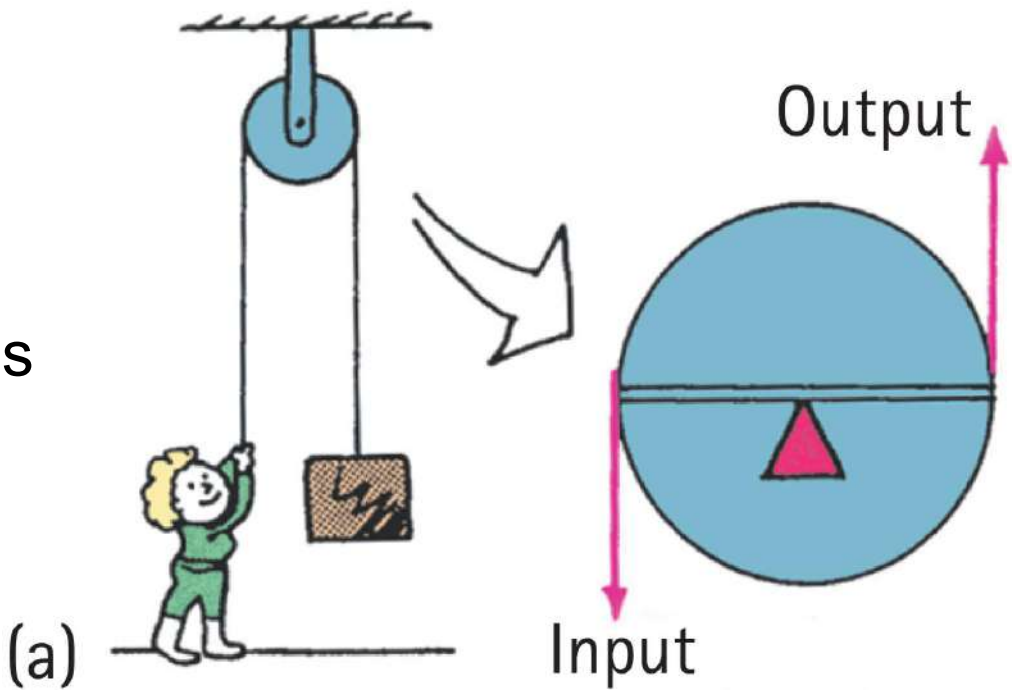


Pulleys, example 1:

- operate like a lever with equal arms

- Example:
  - This pulley arrangement changes only the direction of the input force:

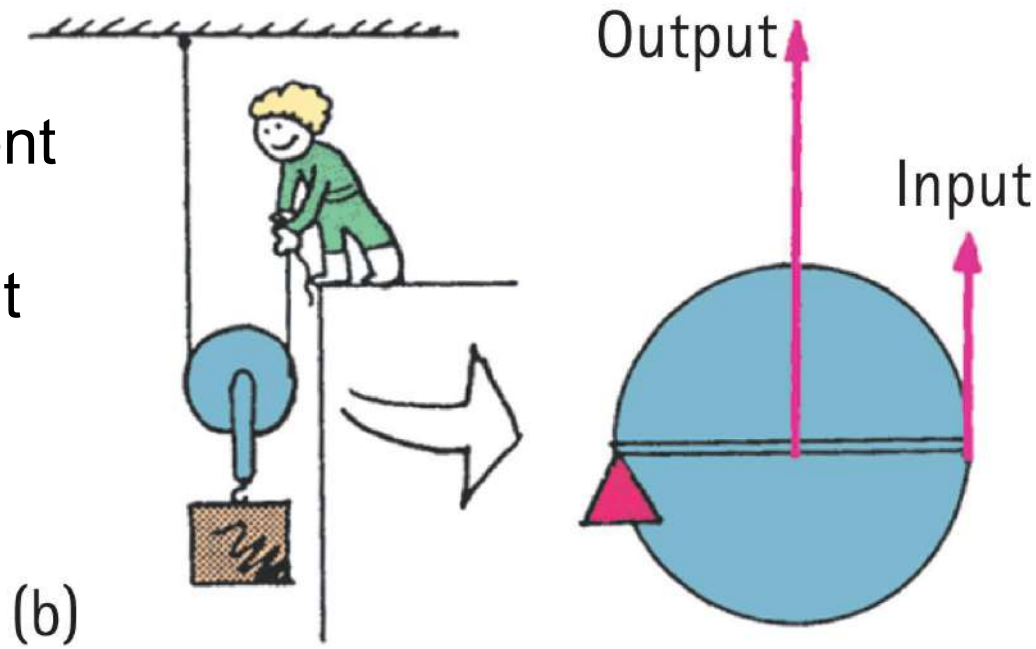
- Why is this helpful in this case?



Machines, Continued-3

- Operates as a system of pulleys (block and tackle)
- Multiplies force

- Example:
  - This pulley arrangement can allow a load to be lifted with half the input force.



Machines: CHECK YOUR NEIGHBOR

In an ideal pulley system, a woman lifts a 100-N crate by pulling a rope downward with a force of 25 N (her input force). For every 1-meter length of rope she pulls (her input distance) downward, the crate rises

A. 50 centimeters.
B. 45 centimeters.
C. 25 centimeters.
D. None of the above.

Work in = work out

Fd in $= Fd$ out

$(25\ \text{N})(1\ \text{m}) = (100\ \text{N})\ d_{out}$

$$d_{out} = \frac{25\ N}{100\ N}(1\ \text{m})$$

$= 0.25$ m

$= 25$ cm

Answer:

In an ideal pulley system, a woman lifts a 100-N crate by pulling a rope downward with a force of 25 N. For every 1-meter length of rope she pulls downward, the crate rises

C. 25 centimeters.

Check:

Work in = *Fd* in = **25 N x 1 m = 25 J**

Work out = Fd out = **100 N x 0.25 m = 25 J**

Which work is greater? **neither**

Which force is greater? **output**

Which distance is greater? **input**

Efficiency

- Efficiency
  - Percentage of work put into a machine that is converted into useful work output
  - In equation form:

$$\text{Efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100\%$$

Ideal

- An ideal machine works at 100% efficiency.
- This never happens.
- Some useful energy is transformed into **thermal** energy (heat). Heat makes things warmer because it increases the kinetic energy of the molecules in the surrounding.
- This molecular KE cannot easily be used to do work, so it is considered “wasted.”

Efficiency
CHECK YOUR NEIGHBOR

A certain machine is 30% efficient. This means the machine will convert

A. 30% of the energy input to useful work—70% of the energy input will be wasted.
B. 70% of the energy input to useful work—30% of the energy input will be wasted.
C. Both of the above.
D. None of the above.

Efficiency
CHECK YOUR ANSWER

A certain machine is 30% efficient. This means the machine will convert

A. 30% of the energy input to useful work—70% of the energy input will be wasted.

Ex. Levers are efficient:

50 J of work are put into a lever, but it only does 47 J of work. Calculate its efficiency.

$$\text{Efficiency} = \frac{\textit{useful energy output}}{\textit{useful energy input}} \times 100\%$$

$$= \frac{47\ \text{J}}{50\ \text{J}} \times 100\%$$

$$= 94\%$$

What percentage of work is wasted as thermal energy?

100% - 94% = 6%

Ex. Pulleys are inefficient:

150 J of work are put into a pulley, but it only does 90 J of work. Calculate its efficiency.

$$\text{Efficiency} = \frac{useful\ energy\ output}{useful\ energy\ input} \times 100\%$$

$$= \frac{90\ \text{J}}{150\ \text{J}} \times 100\%$$

$$= 60\%$$

What percentage of work is wasted as thermal energy?

$$100\% - 60\% = 40\%$$

Recycled Energy

- Re-employment of energy that otherwise would be wasted.
- Edison used heat from his power plant in New York City to heat buildings.
- Typical power plants waste about 30% of their energy to heat because they are built away from buildings and other places that use heat.

Energy for Life

- Body is a machine, so it needs energy.
- Our cells feed on hydrocarbons that release energy when they react with oxygen (like gasoline burned in an automobile).
- There is more energy stored in the food than in the products after metabolism.

Homework: due Wednesday by 7 pm

- On page 127:
- Do #18-22