POINT 3	Power and Efficiency

A. Power is the rate at which work is done, or the rate at which energy is transformed.

$$P = \frac{W}{t} = \frac{Fd}{t} = Fv \qquad \text{(unit: W = J/s)}$$

B. The efficiency of a machine is the ratio of output work (energy) to input work.

$$\text{Efficiency} = \frac{W_{OUT}}{W_{IN}} \times 100\% = \frac{E_{OUT}}{E_{IN}} \times 100\% = \frac{P_{OUT}}{P_{IN}} \times 100\%$$

PROBLEM 6	Power and Efficiency

A crane is driven by a lifting motor. The motor provides power that can lift a 350 kg object at 8.0 m/s. It is observed that in fact the crane lifts a 300 kg concrete block through 25 m vertically in 5.0 s.

a) What is the input power of the crane?
b) What is the power output of the crane?
c) What is the efficiency of the crane?

Solution m_{IN} = 350 kg, v_{IN} = 8.0 m/s, m_{OUT} = 300 kg, d_{OUT} = 25 m, t_{OUT} = 5.0 s

a) $P_{IN} = F_{IN}v_{IN} = m_{IN}g \cdot v_{IN} = (350)(9.8)(8.0) = 27440$ W

b) $P_{OUT} = \dfrac{F_{OUT}d_{OUT}}{t_{OUT}} = \dfrac{m_{OUT}g \cdot d_{OUT}}{t_{OUT}} = \dfrac{(300)(9.8)(25)}{5.0} = 14700$ W

c) $\text{Efficiency} = \dfrac{P_{OUT}}{P_{IN}} = \dfrac{14700}{27440} = 0.54 = 54\%$

RELATED PROBLEMS_____

15. State the definition, type of quantity, and unit of power.

16. A skateboarder increases his kinetic energy from 800 J to 1600 J in 20 s. He expends 1500 J of energy during this activity.

    a) What is his power output?

    b) What is the efficiency of this process?

17. A 1000 kg automobile starts from rest and accelerates along a road to 30 m/s in 15 s. Assume that air resistance and frictional force remain constant at 500 N during this time.

    a) What is the power developed by the engine?

    b) If the automobile is 80% efficient, what is the power developed by the engine?

18. A student pushes a lawn mower 10 m from rest. The graph shows the applied force versus distance.

F (N)

100

40

0   6.0   10   d (m)
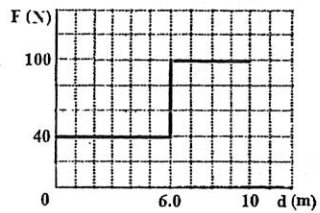
a) How much work does she do moving the lawn mower 10 m?

b) After she pushes the 30 kg lawn mower 10 m, it moves at 5.0 m/s. What is the kinetic energy of the lawn mower?

c) What is the efficiency of this process?

19. The graph shows the potential energy of a model rocket versus time.

PE (J)

60

40

20

0   0.5   1.0   t (s)
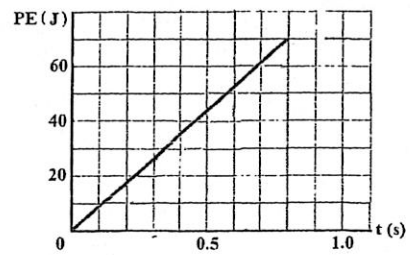
a) Find the power output of the model rocket.

b) If the model rocket is 60% efficient, find the power delivered to the rocket by the engine.

Name:_____

Power and Efficiency

1. How long will it take a 1500 W motor to lift a 400 kg piano to a sixth story window 15.0 m above?

2. If a car generates 15 hp when travelling at a steady 100 km/h, what must be the average force exerted on the car due to friction?

3. Electric energy is often expressed in kilowatts-hours. Show that the Kwh is a unit of energy equal to 3 600 000 J.

4. A shotputter accelerates a 7.3 kg shot from rest to 15 m/s. If this motion takes 2.0 s, what average power was developed?

5. A pump is to lift 4.00 kg of water per minute through a height of 2.85 m. What output rating should the pump motor have?

6. A motor is used for lifting a 150 kg oil barrel. The motor takes 31 s to raise the barrel a distance of 21 m vertically. The efficiency of the motor is 0.58. What is the input power supplied to the motor?

7. A 5.00×10^2 W electric motor lifts a 20.0 kg object 5.00 m in 3.50 s. What is the efficiency of the motor?