Power in Mechanical Systems

1. We will be considering 2 forms of mechanical systems
   a. Linear
   b. Rotational

2. What is power in linear mechanical systems?
   a. Objects move in straight lines
   b. Power is the rate of doing work.
      i. Work is force x distance \((W = F \times d)\)
   c. Machines have power ratings in units of
      i. ft-lbs/sec, Newton-meters/sec, joules/sec, horsepower
   d. Power = work/time = \(W/t\)
      i. But work = force \(\times\) distance, so
      ii. Power = force \(\times\) distance/\(\times\) time, or
      iii. \(P = F \times d/t\), or
      iv. Power = force \(\times\) rate (force \(\times\) speed)
      v. \(P = F \times v\) \(\leftarrow\)

3. What is power in rotational mechanical systems?
   a. Applied torques cause objects to spin or rotate
      i. Torque \((T) = \text{force} \times \text{lever arm} (d)\)
   b. Power is the rate of doing rotational work.
      i. Work is the product of torque \(\times\) swept angle (in radians)
      ii. \(W = T \times \theta\)
   c. Power = rotational work/time, thus
      i. Power = \(T \times \theta/t\)
      ii. But \(\theta/t = \omega\) (angular speed in rads/sec), so
      iii. \(\text{Power} = T \times \omega\) \(\leftarrow\)

4. What are the units of mechanical power?
   a. History - James Watt - donkey(horse)power
   b. British: 1 HP = 550 ft-lbs/sec
c. **Metric**: 1 watt = 1 newton-m/sec = 1 joule/sec

d. Conversion of HP \( \Rightarrow \) Watts

   i. 1 HP = 746 watts = -3.4 kW

5. **Efficiency related to Power?**

   a. Efficiency = work out/work in, or
   
   b. Efficiency = power out/power in

   i. \( E\% = \frac{P_{\text{out}}}{P_{\text{in}}} \times 100 \)

   c. **What comes out is ALWAYS** < what goes in! Always < 100% \( E\% \)

   d. Ex 6-B/p13

6. **What are some uses of mechanical power?**

   a. Harnessing machines to do work

7. **What are the unifying equations for power in mechanical systems?**

   a. Ref p 16

<table>
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<tr>
<th>System</th>
<th>Work</th>
<th>Power</th>
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   | Linear     | \( W = F \times d \) | \( P = \frac{W}{t} \)
   |            |            | \( P = F \times \frac{d}{t} = F \times v \) |
   | Rotational | \( W = T \times \theta \) | \( P = \frac{W}{t} \)
   |            |            | \( P = T \times \frac{\theta}{t} = T \times \omega \) |