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Calculating Horsepower, RPM, and Torque

Horsepower was devised by James Watt, who was famous for his innovations in steam engine development, as a standard by which to compare the power of his early steam engines. He found that the average horse could pull 330 pounds, 100 feet, in 1 minute, which equals 33,000 ft-lb/min. In electrical terms, 1 horsepower is equal to 746 watts. (http://www.wisc-online.com/Objects/ViewObject.aspx?ID=ENG17504)

HP= $\frac{2\pi \cdot T\,(RPM)}{33{,}000} = \frac{T \cdot RPM}{5252}$

Torque is the twisting action developed from a rotating shaft. Force is present at the distance from the center of the twisting action, or the radius. Torque T= force x radius

↖ cross product means the force and lever arm must be ⊥ (normal)

RPM stands for "revolutions per minute".

**When using the horsepower formula, you must first convert all measurements to feet and pounds.

- Sometimes torque will be stated in in-lb, so be careful to convert inches to feet
- Occasionally torque will be stated in in-oz or ft-oz. To use HP formula, always convert to ft-lb

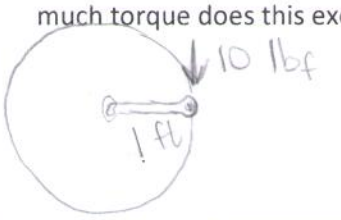
What is the equation for circumference C of a circle? $C = \pi \cdot d = 2\pi r$

Rewrite the HP formula using C as a component:

$HP = \frac{2\pi \cdot (force \times radius)(RPM)}{33{,}000} = \frac{2\pi r(force)(RPM)}{33{,}000} = \frac{C \cdot f(RPM)}{33{,}000}$

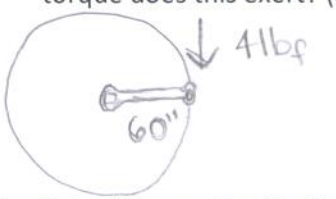
Examples:

1. If I have a wrench with a 1-ft handle, and I apply 10 lbs of force to the end of the wrench, how much torque does this exert? (answer should be in ft-lbs.) Sketch a diagram.



T= force x radius
= 10 lb · 1 ft = 10 ft-lbs

2. If I have a 60-in long wrench, and I apply 4 lbs of force to the end of the wrench, how much torque does this exert? (answer should be in ft-lbs.) Sketch a diagram.



$T = 4\text{ lb} \times 60\text{ in} \times \frac{1\text{ ft}}{12\text{ in}} = 20\text{ ft-lb}$

3. Solve HP equation for Torque T. $HP = \frac{2\pi T(RPM)}{33{,}000}$ or $HP = \frac{T \cdot RPM}{5252}$

$33{,}000\,HP = 2\pi T(RPM)$

$\frac{33{,}000\,HP}{} = T$

$T = \frac{5252 \cdot HP}{RPM}$

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Problems:

1. Calculate Horsepower when Torque= 50.7 ft-lb and RPM=2,317

$$HP = \frac{2\pi T\,(RPM)}{33{,}000} = \frac{2\pi\,(50.7\ \text{ft-lb})\,(2{,}317\ \text{rpm})}{33{,}000} \approx 22.37$$

2. Calculate RPM when Torque= 27.2 ft-lb and Horsepower= 3.5

$$HP = \frac{2\pi \cdot T\,(RPM)}{33{,}000} \Rightarrow RPM = \frac{33{,}000 \cdot HP}{2\pi T} = \frac{33{,}000\,(3.5)}{2\pi\,(27.2\ \text{ft-lb})}$$

$$RPM \approx 675.82$$

3. Calculate Torque when RPM= 484 and Horsepower= 3.7

$$T = \frac{33{,}000\,(3.7)}{2\pi\,(484)} \qquad T \approx 40.15\ \text{ft-lb}$$

4. Calculate Horsepower when Torque= 245.5 in-lb and RPM=1,657

$$HP = \frac{2\pi\,(245.5\ /12)\,(1657)}{33{,}000} \qquad HP \approx 6.45$$

5. Calculate Horsepower when Torque= 98.2 ft-oz and RPM=835

$$HP = \frac{2\pi\,(98.2\ /16)\,(835)}{33{,}000} \qquad HP \approx 0.98$$

6. Calculate Horsepower when Torque= 245.5 in-oz and RPM=3,003

$$HP = \frac{2\pi\,(245.5\ /12\ /16)\,(3{,}003)}{33{,}000} \qquad HP \approx 0.73$$

$$2\pi\left(245.5\ \text{in-oz} \times \frac{1\ \text{ft}}{12\ \text{in}} \times \frac{1\ \text{lb}}{16\ \text{oz}}\right)$$