Rotational Work

Unit: Work, Energy & Momentum
NGSS Standards: N/A
MA Curriculum Frameworks (2006): 2.1, 2.2, 2.3
AP Physics 1 Learning Objectives: N/A

Knowledge/Understanding Goals:
- what rotational work is
- difference between rotational and translational work

Skills:
- calculate the rotational work done of an object

Language Objectives:
- Understand and correctly use the term “rotational work.”
- Set up and solve word problems involving work done on rotating objects.

Notes:
Just as work is done when a force causes an object to translate (move in a straight line), work is also done when a torque causes an object to rotate.

In a rotating system, the formula for work looks similar to the equation for work in linear systems, with force replaced by torque, and (translational) distance replaced by rotational distance (angle) angular velocity:

\[ W = F \cdot d \quad \text{translational} \]

\[ W = \tau \Delta \theta \quad \text{rotational} \]
### Sample Problem

**Q:** How much work is done on a bolt when it is turned 30° by applying a perpendicular force of 100 N to the end of a 36 cm long wrench?

**A:** The equation for work is:

\[ W = \tau \Delta \theta \]

The torque is:

\[ \tau = rF \perp \]

\[ \tau = (0.36)(100) = 36 \text{ N} \cdot \text{m} \]

The angle, in radians, is:

\[ \theta = 30^\circ \times \frac{2\pi \text{ rad}}{360^\circ} = \frac{\pi}{6} \text{ rad} \]

The work done on the bolt is therefore:

\[ W = \tau \Delta \theta \]

\[ W = (36) \left( \frac{\pi}{6} \right) \]

\[ W = 6\pi = (6)(3.14) = 18.8 \text{ N} \cdot \text{m} \]

Note that torque and work are different, unrelated quantities that both happen to have the same unit (N·m). However, **torque and work are not interchangeable!** 36 N·m of torque produced 18.8 N·m of work because of the angle through which the torque was applied. If the angle had been different, the amount of work would have been different.

This is an example of why you cannot rely exclusively on dimensional analysis to set up and solve problems!