Physics Notes – 3/11/2008: Work done by a constant force

Definition of work (W) when force and displacement are in the same direction:

\[ W = Fd \]

SI unit = N • m = joule, J

1 joule = 1 J = 1 N • m = 1 (kg • m/s²) • m = 1 kg • m²/s²

Example 1: A farmhand pushes a 23-kg bale of hay 3.0 m across the floor of a barn. If she exerts a horizontal force of 80.0 N on the hay, how much work has she done?

Example 2: An intern pushes a 72-kg patient on a 15-kg gurney, producing an acceleration of 0.60 m/s². How much work does the intern do by pushing the patient and gurney through a distance of 2.5 m? Assume the gurney moves without friction

- Work = 0 if d = 0, regardless of the force

Definition of work (W) when the angle between the force and displacement is \( \theta \):

\[ W = (F \cos \theta)d = Fd \cos \theta \]

SI unit = joule, J

If \( \theta = 0^\circ \), work = ?

If \( \theta = 90^\circ \), work = ?

Example 3: A 75.0-kg person slides a distance of 5.00 m on a straight water slide, dropping through a vertical height of 2.50 m. How much work does gravity do on the person?
Example 4: A child pulls a friend in a little red wagon with constant speed. If the child pulls with a force of 16 N for 10.0 m, and the handle of the wagon is inclined at an angle of 25° above the horizontal, how much work does the child do on the wagon?

Negative work and total work

- Work depends on the angle between the force, \( F \), and the displacement, \( d \)
- Three distinct possibilities:

  - Cannot assume work is always positive
  - Total work = \( \Sigma W = W_1 + W_2 + W_3 \ldots \)
  - \( W_{\text{total}} = (F_{\text{total}} \cos \theta) = F_{\text{total}} d \cos \theta \)

Example 5:
A car of mass \( m \) coasts down a hill inclined at an angle, \( \phi \). The car is acted on by three forces (ignoring static friction between the tires and the pavement): (i) the normal force \( N \) exerted by the road, (ii) a force due to air resistance, \( F_{\text{air}} \), and (iii) the force of gravity, \( mg \). Find the total work done on the car as it travels a distance \( d \) along the road.

Calculate the total work done on a 1550-kg car as it coasts 20.4 m down a hill with \( \phi = 5.00^\circ \). Let the force due to air resistance be 15.0 N.
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