Unit 7: Work, Energy and Power

1 - Work

Energy: the ability to do work

Work and energy are: Scalar values

Measured in N·m or Joules

Work can be defined as either:

A change in energy or The product of... force + displacement

$W = \Delta E$

$W = Fd$

In physics we talk about work being done... on an object

Ex.

- ☐ If I hold a 30 kg weight at a height of 1.5 m, I'm using energy, therefore I'm doing work
- ☐ However the work is **not** being done to the weight, it is being done on my muscles.
- ☐ *Think of it like this: though I am exerting a force on the weight, its displacement is zero, therefore no work is done on it.*

Ex. If I were to lift the 30.0 kg weight up off the ground to a height of 1.5 m, how much work would be done on the weight?

$m = 30.0\text{ kg}$

$h = 1.5\text{ m}$

$W = mgh$

$= (30.0)(9.80)(1.5)$

$= 440\text{ J}$

When an object is lifted against gravity the formula:

W = Fd

$W = mgh$

Where: m = mass

g = accel due to gravity

h = height

Ex. A 10.0 kg pumpkin is moved horizontally 5.00 m at a constant velocity across a level floor using a horizontal force of 3.00 N. How much work is done in moving the pumpkin?

$m = 10.0\text{ kg}$

$d = 5.00\text{ m}$

$F = 3.00\text{ N}$

$W = Fd$

$= (3.00)(5.00)$

$= 15.0\text{ J}$

Note: Use applied force, not net force

Ex. A 3.0 kg pineapple is held 1.2 m above the floor for 15 s. How much work is done on the pineapple?

$m = 3.0\text{ kg}$

$h = 1.2\text{ m}$

$t = 15\text{ s}$

$W = mgh$

$= (3.0)(9.8)(1.2)$

0

Note: No displacement means no work done on the object.

Ex. A 50.0 kg banana box is pulled 11.0 m along a level surface by a rope. If the rope makes an angle with the floor of 35° and the tension in the rope is 90.0 N, how much work is done on the box?

$m = 50.0\text{ kg}$

$d = 11.0\text{ m}$

90.0 N, 35°, x — SOH CAH TOA

$90\cos 35 = x$

$x =$

$W = Fd$

Note: Use on the only component of the force that is in the direction of displacement

Ex. A 1385 kg car traveling at 61 km/h is brought to a stop while skidding 42 m. What is the work done on the car by frictional forces?

$m = 1385\text{ kg}$

$v_i = 61\text{ km/h} = 16.9\text{ m/s}$

$v_f = 0$

$d = 42\text{ m}$

$W = ?$

$W = Fd$

$= (4709)(42)$

$= 1.98 \times 10^5\text{ J}$

$F = ma$

$v^2 = v_0^2 + 2ad$

$\frac{-(16.9)^2}{2(42)} = a$

-3.4

Note: Work can be Negative if the force doing the work acts in the negative direction.

Worksheet 7.1: **Work**

1. A 20.0 N pomegranate is lifted at a constant velocity from the floor to a height of 1.50 m. How much work is done on the object?

$W = mgh$
$= (20.0)(9.80)(1.50\text{m})$
$= 294\text{ J} = 300\text{ J}$

2. A 15.0 N potato is moved horizontally 3.00 m across a level floor using a horizontal force of 6.00 N. How much work is done on the potato?

$W = Fxd$
$= (6.00)(3.00)$
$= 18.0\text{ J}$

3. A 2.20 N pear is held 2.20 m above the floor for 10.0 s. How much work is done on the pear?

$W = Fxd$
$= 0\text{ J}$

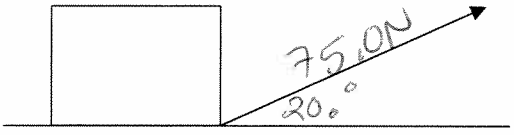
4. A 10.0 kg pink grapefruit is accelerated horizontally from rest to a velocity of 11.0 m/s in 5.00 s by a horizontal force. How much work is done on the pink grapefruit assuming no friction?

$m = 10.0\text{kg}$
$V_i = 0$
$V_f = 11.0\text{m/s}$
$t = 5.00\text{s}$
$d = 27.5$

$a = \frac{V - V_0}{t} = 2.2\text{m/s}^2$
$F = ma = (2.2)(10) = 22\text{N}$
$W = (22\text{N})(27.5\text{m})$
$W = 605\text{ J}$

$\frac{V^2 - V_0^2}{2a} = d$ $\quad \frac{11^2}{2(2.2)} =$

5.



A 90.0 N box of papayas is pulled 10.0 m along a level surface by a rope. If the rope makes an angle of 20.0° with the surface, and the force in the rope is 75.0 N, how much work is done on the box?

75 @ 20° = F_x

$75.0\cos 20° = F_x$
$F_x = 70.48\text{N}$

$W = Fxd$
$= (70.48\text{N})(10.0\text{m})$
$= 705\text{ J}$

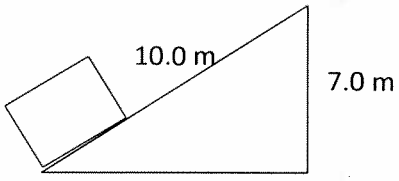
6. A 60.0 kg student runs at a constant velocity up a flight of stairs. If the height of the stairs is 3.2 m, what is the work done against gravity?

$W = mgh$
$(60.0)(9.80)(3.2)$
$= 1900\text{ J}$

7. A 20.0 kg passionfruit is pulled horizontally 9.0 m along a level frictionless surface at a constant velocity. How much work is done on the passionfruit?

$F = ma$ $\quad a = 0$ $\quad F = 0$ $\quad \therefore W = 0$

8.



An 80.0 kg pumpkin is pushed up at a constant velocity along a frictionless incline as shown in the diagram. How much work is done on the pumpkin in moving it up the incline?

$W = mgh$
$= (80.0)(9.80)(7.0\text{m})$
$= 5500\text{ J}$

9. A 25.0 kg pickle is accelerated from rest through a distance of 6.0 m in 4.0 s across a level floor. If the friction force between the pickle and the floor is 3.8 N, what is the work done to move the object?

$V_i = 0$
$d = 6.0\text{m}$
$t = 4.0\text{s}$
$V_f = ?$

$F_f = 3.8\text{N}$

$a = \frac{2d}{t^2} - \frac{V_0 t}{t^2} = \frac{2(6)}{4^2} - 0.17\text{m/s}^2$

$F_{net} = ma$
$F_{app} = ma + F$
$= (25)(0.75) +$
$= 22.55\text{N}$

$W = Fxd$
$= (22)(6$

10. A 1165 kg car traveling at 55 km/h is brought to a stop while skidding 38 m. Calculate the work done on the car by the friction forces.

$m = 1165\text{kg}$
$V_i = 15.3\text{m/s}$
$V_f = 0$
$d = -38\text{m}$

$F = ma$ $\quad \frac{V^2 - V_0^2}{2d} = a$ $\quad a = \frac{(15.3)^2}{2(-38)} =$

$a = 3.07\text{m/s}$

$F = (1165)(3.07) = 3.58$

$W = Fxd$
$= (3.58\text{N})(38$
$= 1.4 \times 10^5\text{ J}$

135 J

1) 30.0 J 2) 18.0 J 3) 0 J 4) 605 J 5) 705 J 6) 1900 J 7) 0 J 8) 5500 J 9) 135 J 10) 1.4×10^5 J