Phys 111 2023

Lecture 24

Mon: HW by 5pm

Ex. 220, 221, 222, 225, 228, 229, 231

Ch 10 Prob 8

Mon: Group Ex (graded)

Work and kinetic energy

If a constant force acts on an object that moves in a straight line then the work done by the force is

$$\boxed{W = \underset{\text{magnitude force}}{F}\,\underset{\text{distance traveled}}{d}\cos\theta}$$

θ — angle between force and displacement.

This is a number (no direction) that can be positive, negative or zero.

Quiz 1 30% → 70%

This relates to motion through kinetic energy

> An object with mass moving with speed v has kinetic energy
>
> $$K = \tfrac{1}{2}mv^2$$
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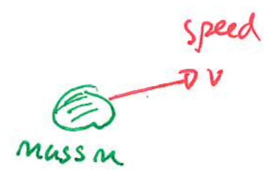
> 
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Then in all situations (Work-Kinetic Energy Theorem)

> Consider the motion of an object over a period of time. Then let W_{net} be the net work done during this period. Then
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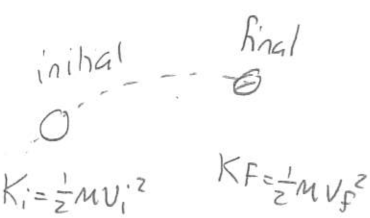
> 
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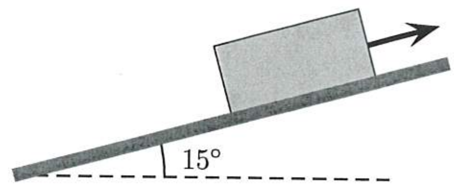
>
> $$W_{net} = \Delta K = K_f - K_i$$
> $$= \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2$$

Warm Up 1 (2 from previous)

226 Box lowered down a frictionless ramp

A 5.00 kg box is at rest at the top of a frictionless ramp that is inclined at 15° from the horizontal. The length of the ramp is 8.00 m. A rope pulls on the crate with a ~~18.0~~N force parallel to and up the ramp. *(111F2023)*



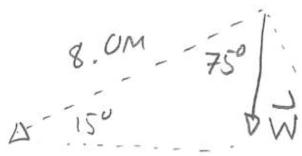
9.0N

a) Determine the work done by gravity on the box from the top to bottom of the ramp.

b) Determine the work done by the rope on the box from the top to bottom of the ramp.

c) Determine the speed of the box at the bottom of the ramp.

Answer: a)



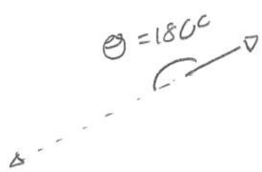
$W = mg = 5.00\,\text{kg} \times 9.8\,\text{m/s}^2$

$= 49\,\text{N}$

$W_{grav} = F_{grav}\, d \cos 75° = 49\,\text{N} \times 8.0\,\text{CM} \times \cos 75°$

$= 101\,\text{J}$

b)



$W_{rope} = F_{rope}\, d \cos 180°$

$= 9.00\,\text{N} \times 8.00\,\text{m} \times (-1)$

$= -72\,\text{J}.$

c) Need net work $W_{normal} = 0\,\text{J}$. Then

$W_{net} = W_{grav} + W_{rope} + W_{normal} = 101\,\text{J} - 72\,\text{J} = 28\,\text{J}$

$\Rightarrow \Delta K = 28\,\text{J} \Rightarrow K_f - K_i = 28\,\text{J}$ $\qquad K_i = \frac{1}{2} m \cancel{v_i}^2 = 0\,\text{J}$

$\Rightarrow K_f = 28\,\text{J}$

$\Rightarrow \frac{1}{2} m v_f^2 = 28\,\text{J} \Rightarrow \frac{1}{2}\, 5.00\,\text{kg}\, v_f^2 = 28\,\text{J}$

$\Rightarrow v_f^2 = \frac{28\,\text{J}}{5.00\,\text{kg}}\, 2 = 11.2\,\text{m}^2/\text{s}^2$

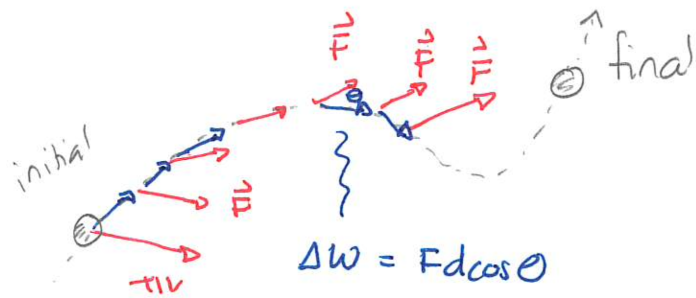
$\Rightarrow v_f = \sqrt{11.2\,\text{m}^2/\text{s}^2} = 3.3\,\text{m/s}$

Work done by variable forces with curved paths

In general forces can vary (e.g. gravitational force exerted by planet) and it is also possible that the trajectory is not straight. The definition of work must be modified for these situations. In this case we break the trajectory into small pieces. Each is approximately straight and

$\Delta W = Fd\cos\theta$

will give an incremental amount of work on each. We then add these incremental works to arrive at the work done over the entire path.



Quiz 2 80% - 95%

Quiz 3 80%

Quiz 4 80%

end

Work done by gravity: gravitational potential energy

We aim to replace work calculations by simpler methods especially when paths are curved. For example consider an object moving under Earth's gravitational force. If the object moves vertically down then

$$W_{grav} = F_{grav}\, d\cos\theta$$

$$= mg(y_i - y_f)\cos 0°$$

$$= mgy_i - mgy_f$$