Review Phys 11 Work-Energy-Power - Notes for the Video Lesson

Topic: Mechanical Energy and Power – ***Physics 11 textbook*** **Chapter 4.3, 4.4, and 4.6**

Key concepts and equations:

Video lesson 1: https://www.loom.com/share/a412df9d5dc64a208166f457e681a05c

Types of Mechanical Energy:

- Gravitational Potential Energy: $E_g = mgh$
- Kinetic Energy: $E_K = ½mv^2$

Work Energy Theorem: Net Work = Change in Kinetic Energy

$\Sigma W = \Delta E_K$

Power = Rate of doing work $P = W/t = \Delta E/t$

Video lesson 2: https://www.loom.com/share/6bff4e04621340cc8b8339164af69be3

Conservation of Energy: $E_i + W_{nc} = E_f$

$E_{gi} + E_{Ki} + W_{nc} = E_{gf} + E_{Kf}$

$mgh_i + ½mv_i^2 + W_{nc} = mgh_f + ½mv_f^2$

Efficiency: *efficiency* = [energy output/energy input]×100%

efficiency = $[E_{out}/E_{in}]$×100%

Lesson:

- Theory (development of equations, with unit analysis)
- Examples of problem solving strategies
- ~~***Assignment:***~~
  - ~~Week of April 20 – textbook theory questions and problems~~
  - ~~Week of April 27 – mini-project:~~
  - ~~***Case study*** – the physics of a sport or activity~~

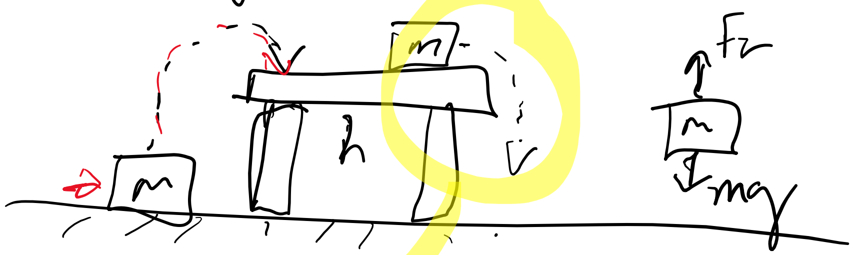
Lesson #1 → Ch 4.3 + 4.4 + 4.6

mechanical energy → Kinetic energy = energy of motion

→ Gravitational potential energy

G.P.E. = E_g

GPE = E_g

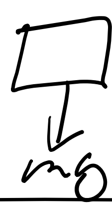


Work = $F_L \times d$

$W = F_L \times h$

minimum $F_L = mg$

$W = mgh$ ground to table top.



$W_{F_g} = F_g \times \Delta h = mgh$

Gravitational P.E. = mgh

$W = \Delta E$

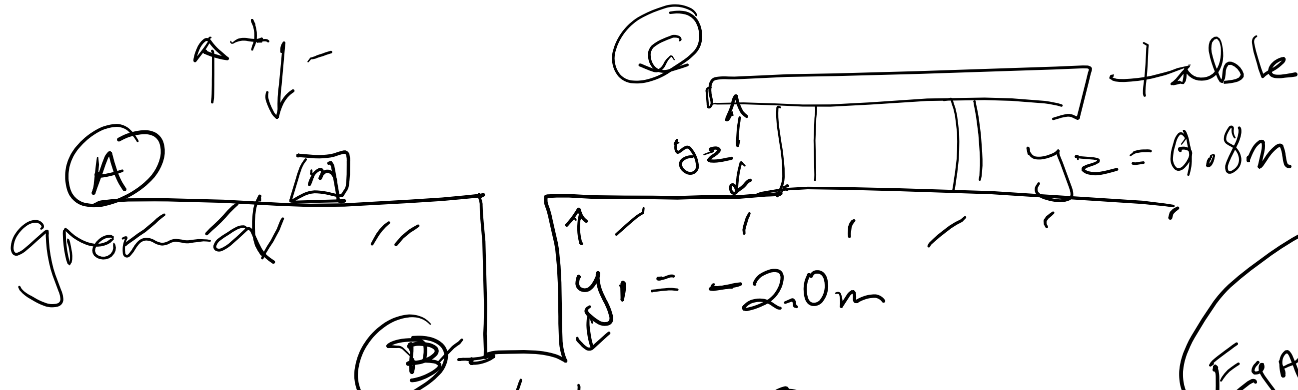
(kg)(N/kg)(m)

(N·m)

(J)

Definition of frame of reference

- where is $h = 0$? ?



$E_{gA} = 0J$

if ground level (A) is $h_A = 0m$

at (B), $E_{gB} = mgy_1 = mg(-2.0m) = ?$

at (C) $E_{gC} = mg(0.8m) = ?$

BUT if $h = 0m$ at B

$E_{gA} = mgh_A = mg(2.0m) =$ ____ J

$E_{gB} = mgh_B =$ 0J

$E_{gC} = mgh_C = mg(2.8m) =$ ____ J

Kinetic Energy = energy of motion

$E_k = \frac{1}{2} m v^2$

mass → m, speed → v

unit: $(kg)\left(\frac{m^2}{s^2}\right) = J$

Work - energy theorem ← mathematical relationship

$W_{net} = \sum \vec{F} \times \Delta \vec{d}$

$\sum \vec{F} = m\vec{a}$

$W_{net} = m\vec{a} \cdot \Delta \vec{d}$

$v_f^2 = 2\vec{a}\Delta\vec{d} + v_i^2$

$\frac{2\vec{a}\Delta\vec{d}}{2} = \frac{v_f^2 - v_i^2}{2}$

$W_{net} = m\left[\frac{v_f^2 - v_i^2}{2}\right]$

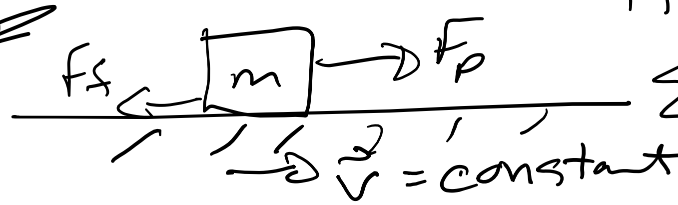
$W_{net} = \frac{mv_f^2}{2} - \frac{mv_i^2}{2}$

$KE = E_k = \frac{1}{2}mv^2$

$W_{net} = E_{k_f} - E_{k_i} = \Delta KE$

= Work - Energy Theorem

e.g.

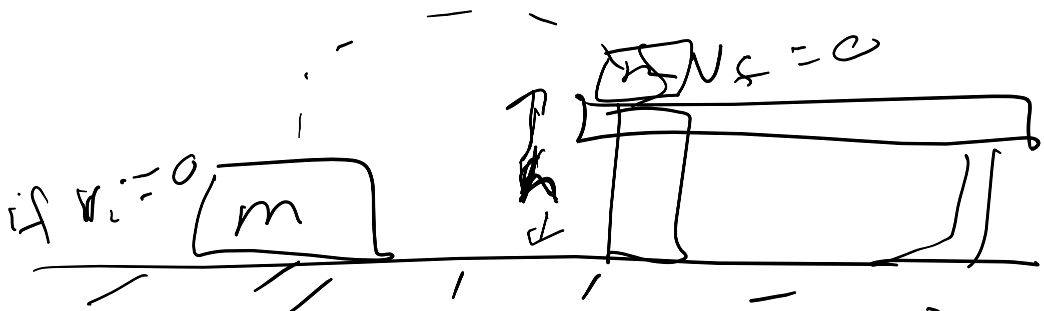


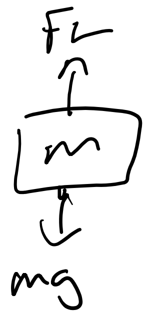
if $F_p = F_f$

$\sum F = 0$

$\Delta KE = 0$

∴ $W_{net} = 0 J$





$$\sum W = \Delta KE = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

($v_f = 0$, $v_i = 0$)

$$\therefore \boxed{\sum W = 0\,J}$$

F_L does + work on the mass

and F_g does − work " " "

But

$$\boxed{\sum W = W_{net} = \Delta KE = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2}$$

from (A) → (B) ΔKE is − (slowing)

so net $W = -mg\Delta y$

from (B) → (A) ΔKE is + (speeding up)

so net $W = mg\Delta y$

from (A) → (C) $\boxed{W_{net} = \Delta KE = \frac{1}{2}mv_C^2 - \frac{1}{2}mv_A^2}$

4.6

Power = rate of doing work

$$P = \frac{W}{t} = \frac{\Delta E\ (J)}{t\ (s)}$$

P (Watt) = ___ (J/s)

$\Delta E = P \cdot t$
(W) · (S)

Hydro Bill — kW · h

VIDEO LESSON #2 – Conservation of Energy and Efficiency – Chapter 4.4

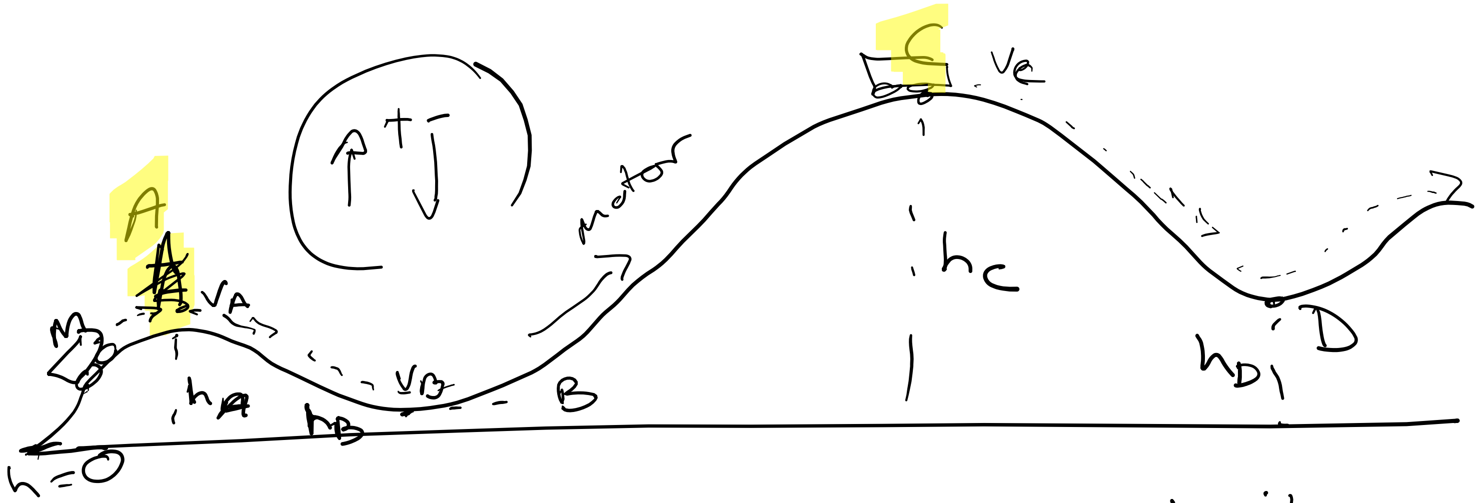
$E_g = mgh$

$E_k = \frac{1}{2}mv^2$

$\Sigma W = \Delta KE$

$$P = \frac{W}{t} = \frac{\Delta E}{t}$$

eg: roller coaster



cons. of Energy = energy isn't created or destroyed but can change form (Energy transformations)

if magical frictionless roller coaster

(C) → (D) (gravity only)

$$E_{Total\,C} = E_{Total\,D}$$

$$E_{gC} + E_{KC} = E_{gD} + E_{KD}$$

$$mgh_C + \frac{1}{2}mv_C^2 = mgh_D + \frac{1}{2}mv_D^2$$

$$2gh_C + v_C^2 = 2gh_D + v_D^2$$

$$v_D^2 = 2gh_C - 2gh_D + v_C^2$$

$$v_D^2 = 2g(h_C - h_D) + v_C^2$$

same as → kinematics eq'n (no friction + no motor)

$$\boxed{v_f^2 = 2g(h_i - h_f) + v_i^2}$$

Non-Conservative forces

involve transforming mechanical energy → other forms

- gravitational P.E.
- kinetic E.

e.g. heat, sound, light

eg. Motor: chem PE (fuel) → KE

parked $v_i = 0$ $\quad\quad$ $v_f > 0$

$$E_i \neq E_f$$

$$E_i + W_{nc} = E_f$$

$$mgh_i + \frac{1}{2}mv_i^2 + W_{nc} = mgh_f + \frac{1}{2}mv_f^2$$

level road $\therefore h_i = h_f$

$$W_{nc} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$W_{nc} = \Delta E_k$$

W_{nc} = work done by non-conservative forces

eg. $W_{nc} = F_f \times \Delta d$ (removes mech Energy)

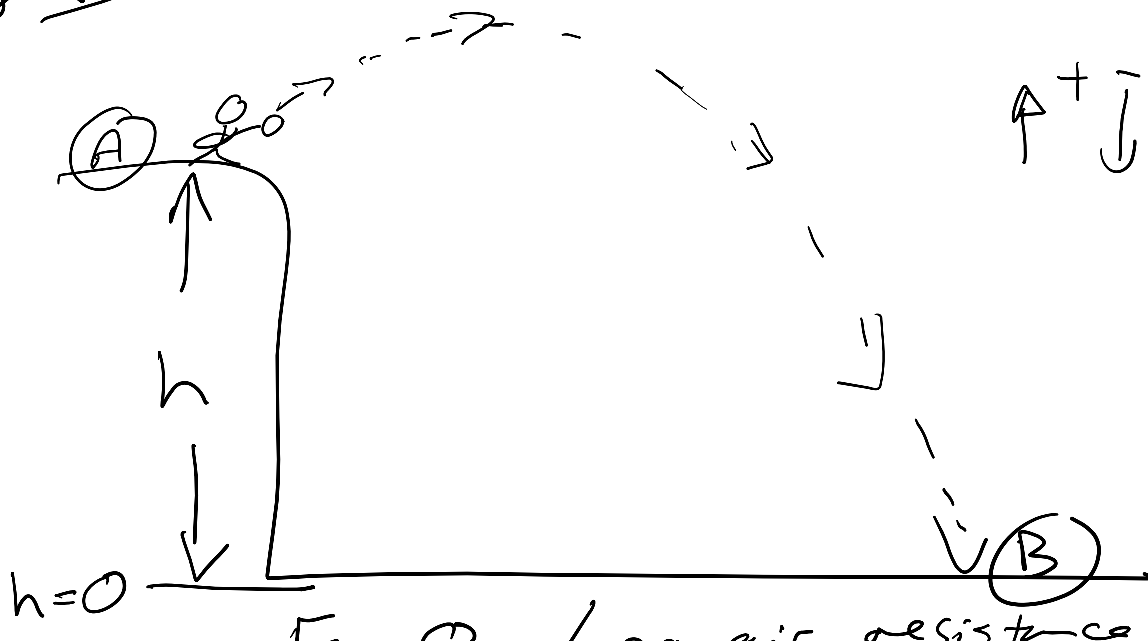
eg. W_{nc} by motors. (adds mech Energy) eg roller coaster.

$$E_{TA} + W_{nc} = E_{TC}$$

$$mgh_A + \frac{1}{2}mv_A^2 + W_{nc} = mgh_C + \frac{1}{2}mv_C^2$$

(eg motor + friction)

eg projectile.



$F_f = 0$ (no air resistance)

$$W_{nc} = 0$$

$$E_A = E_B$$

$$\cancel{m}gh_A + \frac{1}{2}\cancel{m}v_A^2 = \cancel{mgh_B}\;0 + \frac{1}{2}\cancel{m}v_B^2$$

$$2gh_A + v_A^2 = v_B^2$$

$$v_f^2 = 2\vec{a}d + v_i^2$$

$$v_B = \sqrt{2gh_A + v_A^2}$$

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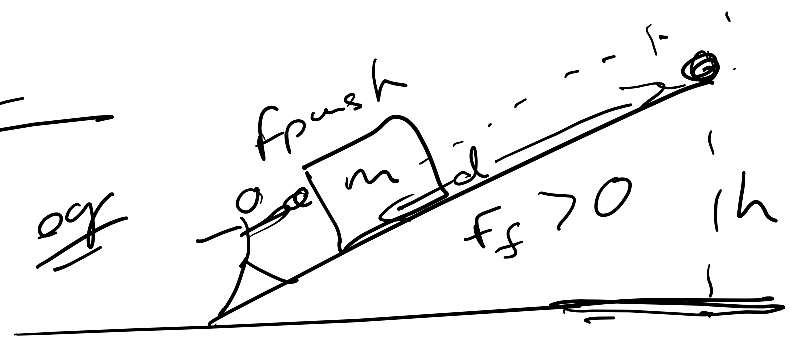
efficiency



$W_{output} = mgh$

$W_{input} = F_{push} \times \Delta d$ (along ramp)

if $F_f > 0$ some of your work input will be transformed in heat and sound.

$$eff = \left[\frac{E_{out}}{E_{in}}\right] \times 100\%$$

$$= \left[\frac{mgh}{F_{push} \times \Delta d}\right] \times 100\% = \_\_\_\_$$