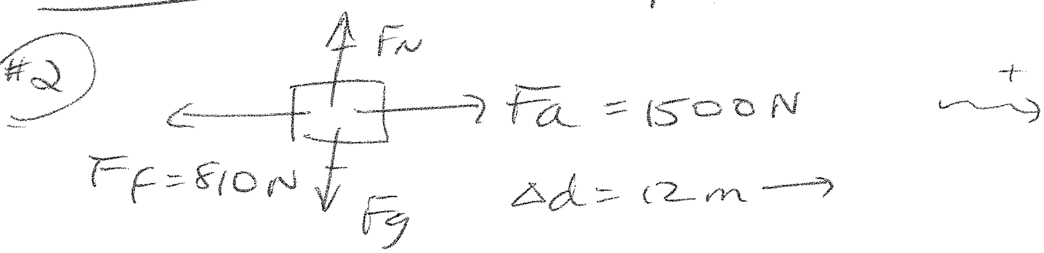
5.1 WORK

p. 229 2–11 (not 5)

#2

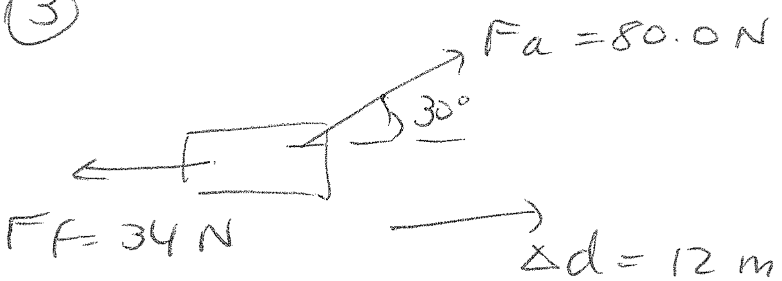


a) Work of $F_a \Rightarrow$ $W_{mech} = Fd = (1500\,N)(12\,m) = \underline{^{+}18000\,J}$

b) work of $F_f \Rightarrow$ $W_f = Fd = (-810)(12\,m) = \underline{^{-}9700\,J}$

c) } The car does <u>not</u> move vertically $\therefore \Delta d = 0$
d) }
$W = Fd = \underline{0}$ <u>No</u> work done by F_g or F_N.

3



a) $W_{Mech} = ? \Rightarrow$ $W = F\cos\theta\,\Delta d$
$= 80 \cdot (\cos 30)(12) = \underline{^{+}830\,J}$
(831)

b) $W_{TOTAL} = ?$ (or W_{net})

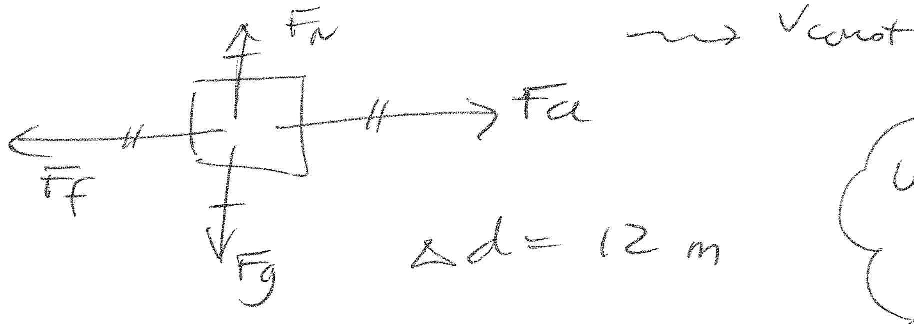
$W_{friction} = Fd = (-34)(12) = \underline{-408\,J}$

$W_{TOTAL} = W_{Mech} + W_{F_f}$ (use above calculation with extra sig digs)

$= {}^{+}831 + (-408)$
$= 423$

$\boxed{\text{Total Work} = {}^{+}420\,J}$

#4



a) $\Delta d = 12$ m

BTW...

why do last 3 questions all have $\Delta d = 12$m? -very unimaginative-

if box @ constant velocity
$\therefore F_f = F_a$ (balanced forces)

b) Tension is drawn as Fa.
The rope is said to do 250 J of work.

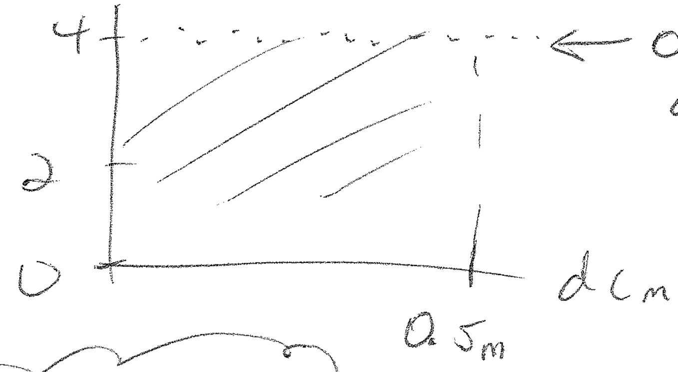
$\therefore W_{mech} = 250$ J
$250 = Fd$
$250 = F_a(12)$ $\quad (F_a = T)$
$\therefore F_a = 20.8 = \underline{21\ N}$

c) $F_f = ?$
$W_f = ?$

$F_a = F_f$ $\therefore$ Friction $= \underline{21\ N}$ (opposite direction)

and $W_f = \underline{-250\ J}$
(same force but opp<u>osite</u> direction)

#6



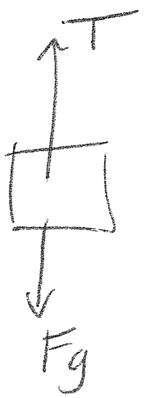
← oscillates a little above/below 4 N
$\therefore F_a = \underline{4N}$
on average

all above zero

W = area under graph
$\therefore W = Fd = (4\ N)(0.5m) = 2\ Nm = \underline{+2\ J}$

#7

up



$a = 2.2\ m/s^2$ $\quad t = 3.0\,s \quad v_1 = 0$

$m = 2.0\ kg$

$(T > F_g)$

a) $\Delta d = ?$ <u>kinematics</u>

$d = v_1 t + \frac{1}{2} a t^2$

$d = 0 + \frac{1}{2}(2.2)(3)(3)$

$\underline{d = 9.9\,m\ [up]}$

b) $W_{mech} = ?$

$W_{grav} = ?$

need to find T and F_g

② expand out $F_{net} = ma$

① $F_g = mg$

$F_g = mg = (2.0)(9.8)$

$\underline{F_g = 19.6\ N}$

$W_{grav} = (F_g)(d)$

$= (-19.6)(9.9)$

$= -194\ J$

$\underline{W_{grav} = -190\ J}$

$F_{net} = ma$

$F_g + T = (2)(2.2)$

$-19.6 + T = 4.4$

$T = 4.4 + 19.6$

$\underline{T = {}^{+}24\ N\ [up]}$

$W_{mech} = (T)(d)$

$= (+24)(9.9)$

$= +237.6$

$\underline{W_{mech} = +240\ J}$

c) $W_{TOTAL} = ?$ $\quad W_{TOTAL} = W_T + W_{grav}$

$= {}^{+}237.6 + (-194)$

$W_{TOTAL} = {}^{+}\underline{44\ J}$

d) $F_{net} = T + F_g$

$= {}^{+}24 + (-19.6)$

$\underline{F_{net} = {}^{+}4.4\ N}$

Work done by F_{net}

$W = F_{net} \cdot d$

$= (4.4)(9.9)$

$W_{net} = \underline{44\ J}$

Same!

– 2 ways to get there –

#8.

a) __No__ mechanical work (since $\Delta d = 0$)

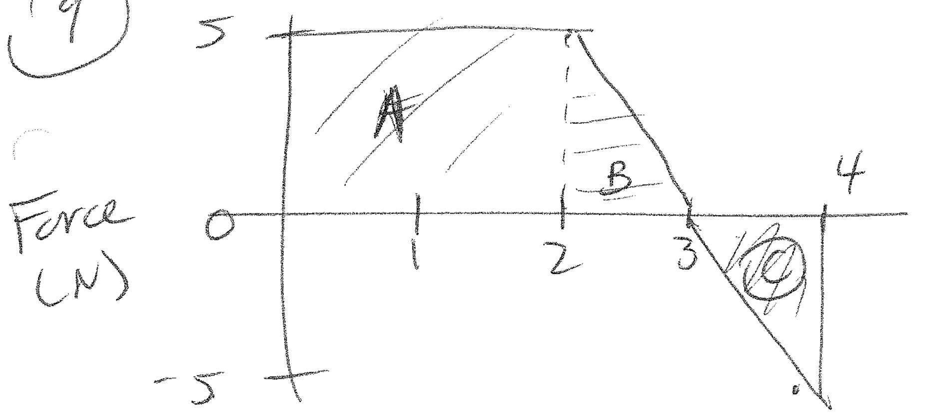
b) __NO__ " " (since $\Delta d = 0$)

c) pushing? – yes ^{+}W (F ✓ Δd ✓)

lets go + moves on frictionless rollers?

__NO__ work (no $\underline{F}$)

9



W = area under graph to zero line.
$\therefore$ A+B ⇒ +W
C ⇒ −W

a) $W_A = (5\,N)(2\,m) = +10\,J$

$W_B = \frac{1}{2}(1\,N)(5\,m) = +2.5\,J$

$W_C = \frac{1}{2}(1\,N)(-5) = -2.5\,J$

b) $W_{TOTAL} = +10 + 2.5 + (-2.5) = \underline{+10\,J}$

c) W_C must be negative since F = −5 N.
This shows ⇒ $W = Fd$
$= (-5)(+1\,m) = -5N$

OR understand that means Force is in opposite direction to movement of box. (Maybe a backward force is slowing box down)

10 Determine work?
#1 → Formula $W = Fd$
#2 → area under Force/displacement graph.

#11 $W = F(\cos\theta)\Delta d$

a) when Force is perpendicular to Δd,

$\theta = 90°$

and $\cos 90° = 0$

$\therefore W = 0$.

b) when force is opposite in direction to Δd,

then $\theta = 180°$

and $\cos 180° = \underline{\underline{-1}}$

$\therefore$ The changes the sign of the resulting work from +ve to $\underline{\underline{-ve}}$.

5.2 Energy p. 235 # 1, 2, 5, 6

#1 $m = 610$ kg

$E_K = 40.0$ kJ $= 40{,}000$ J

$v = ?$

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

$40{,}000 = \frac{1}{2}(610) v^2$

$v = \sqrt{\frac{2 \times 40{,}000}{610}} = 11.45 = \underline{\underline{11 \text{ m/s}}}$

#2 $m = 0.160$ kg

a) $v_1 = 0$

$v_2 = 22$ m/s

$\Delta d = 1.2$ m

} puck hit by stick

<u>final E_K</u> $= \frac{1}{2} m v^2$

$= \frac{1}{2}(0.160)(22)(22) = 38.72$

$= \underline{\underline{39 \text{ J}}}$

b) $F_{net} = ma$

find

assume $F_f = 0$ on ice

$\therefore F_{net} = F_a$ by stick

$v_2^2 = \cancel{v_1^2} + 2ad$

$(22)(22) = 0 + 2a(1.2)$

$a = +202$ m/s^2 !

$\therefore F_{net} = ma$

$= (0.160)(200)$

$= \underline{32\ N}$

2ND way

$W = Fd$
? ✓

and $W = \Delta E_K$

$\therefore Fd = \Delta E_K$

$Fd = E_{K_2} - E_{K_1}$

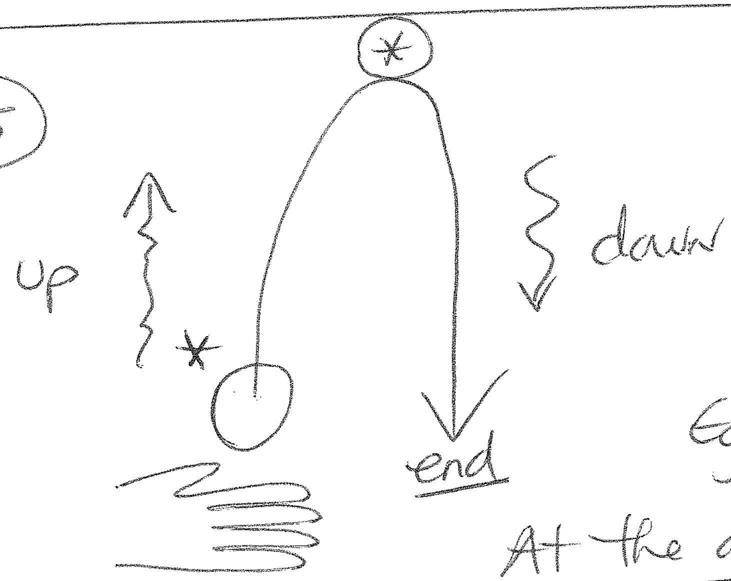
$E_{K_1} = 0$ because $V_i = 0$ m/s

$F(1.2) = 38.72 - 0$

↑ answer from (a)

$F = \underline{32 N}$

#5



On the way up, it starts * with a lot of E_K but loses E_K and gains E_g as it goes up.

At the apex ⊛ there is all E_g and momentarily no E_K.

ON the way down the reverse happens: $E_g \rightarrow E_K$

Just before it is caught, its maximum E_K

#6 : • pulled to top of drop tower

= gaining E_g!

It is stored there as they are being held @ top

• released

— lose E_g but gaining E_k

($E_g \longrightarrow E_k$)

so... dropping faster & faster

• slowed at bottom?

losing E_k (slowing) + also losing E_g (lowering)

where does it go?

likely heat + sound from braking system.

5.3 Types of Energy & Energy Conservation

p. 241 #1, 2, 3

1. a) $E_g \rightarrow E_K$

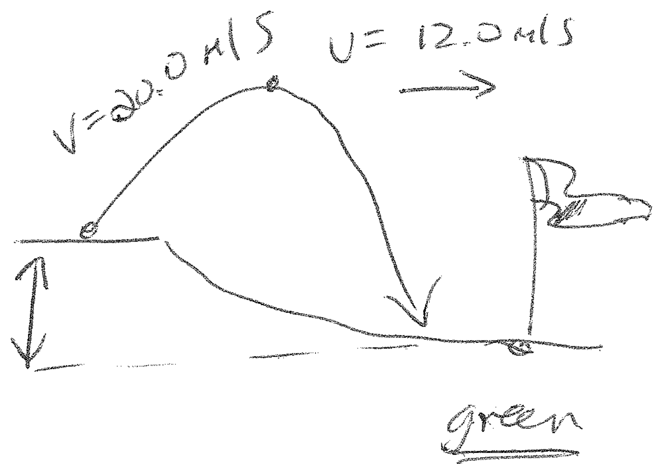
   b) $E_e \rightarrow E_K$
   elastic

   c) $E_{CHEM} \rightarrow E_{LIGHT} + E_{THERMAL} + E_{SOUND}$

   d) $E_{el} \rightarrow E_{light} + E_{THER.}$
   electrical

   e) $E_{CHEM} \rightarrow E_K$

2. $m = 0.0459$ kg
   $h = 8$ m
   $v = 20.0$ m/s



* Assume $E_g = 0$ at green

* note: at apex all motion is ~~vertical~~ horizontal. It would still have $v = 0$ m/s in the vertical ↕ plane.

$E_{mech} = ?$

* note: $E_{MECH} = E_K + E_g$

start

$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(0.0459)(20)(20) = \underline{9.18\text{ J}}$

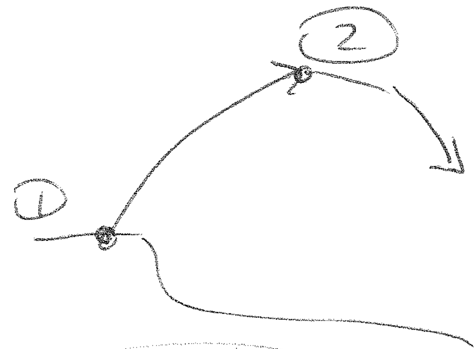
$E_g = mgh = 0.0459(9.8)(8) = \underline{3.60\text{ J}}$

12.8 J

E_{mech} @ start

b) Max height = ?

use $E_{T_1} = E_{T_2}$



$E_{T_1} = 12.8$

$12.8 = E_{K_2} + E_{g2}$

$12.8 = \frac{1}{2}(0.0459)(12)(12)$

$+ (0.0459)(9.8)h$

$E_{K_2} \neq 0$! still moving 12 m/s → horizontally

$12.8 = 3.305 + 0.450\,h$

$h = 21$ m

c) speed when it hits?

$E_{T_1} = E_{T2}$

$12.8\text{ J} = E_{K_2} + \cancel{E_{g2}}^{\,0}$

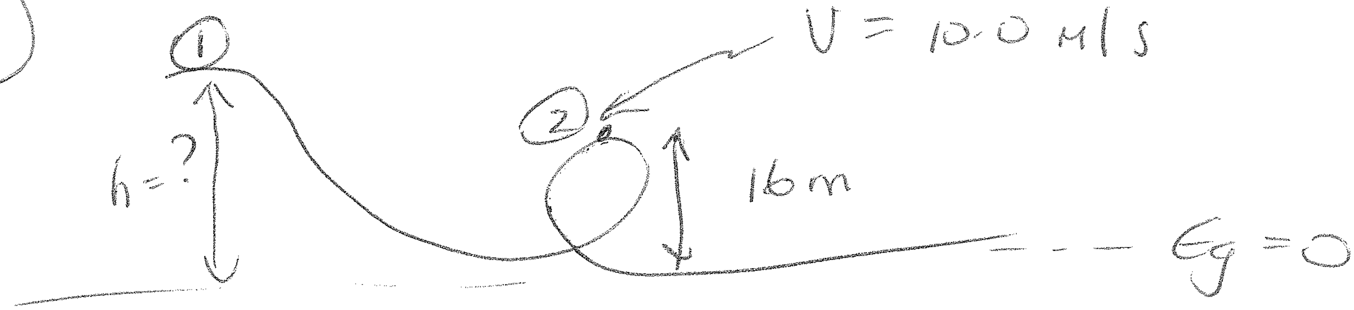
* in (a) assumed

$12.8 = \frac{1}{2}(0.0459)v^2$

$v = \sqrt{558}$

$v = 24$ m/s

3



1 $V = 0$ m/s
$h = ?$
mass = $\underline{m}$
(not given)

2 $v = 10.0$ m/s
$h = 16$
mass = m

$$E_{T_1} = E_{T2}$$

$$\cancel{E_{k_1}} + E_{g_1} = E_{k_2} + E_{g2}$$

$$0 \quad m(9.8)h = \tfrac{1}{2}m(10)(10) + m(9.8)(16)$$

$$9.8\,mh = 50\,m + 156.8\,m$$

$$9.8\cancel{m}h = \cancel{m}(50 + 156.8)$$

$$h = 21\text{ m}$$

5.4 Efficiency   p. 249 # 1, 2, 3, 6, 7

(1)

$v_1 = 0$ $v_2 = 11\ m/s$

$m = 54\ kg$

efficiency = 85 %

$E_{IN} = ?$

$E_{out} = E_K$

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

$= \frac{1}{2}(54)(11)(11)$

$= 3267\ J$

$$\%\ \text{efficiency} = \frac{\text{energy out}}{\text{energy IN}} \times 100\%$$

$$85 = \frac{3267}{\text{energy IN}} \times 100$$

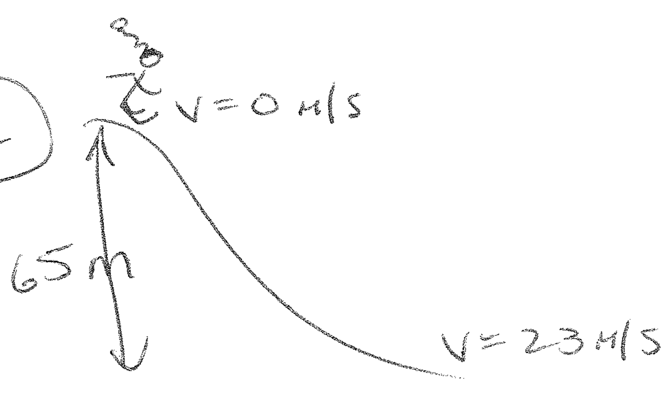
$$0.85 = \frac{3267}{\text{energy in}}$$

$$E_{IN} = 3843$$

$E_{IN} = 3.8\ kJ$

(3800 J)

(2)



% efficiency ?

$E_g \rightarrow E_K$ $\therefore$ $E_g = E_{IN}$

$E_K = E_{out}$

$$\% \text{ eff} = \frac{E_{out}}{E_{in}} \times 100\%$$

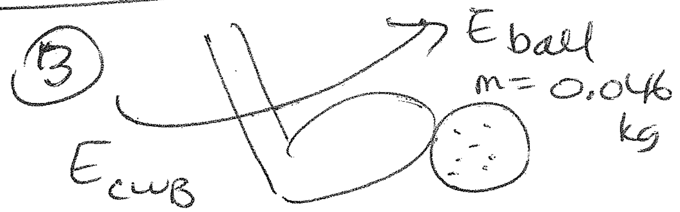
$$= \frac{\frac{1}{2} \cancel{m} v^2}{\cancel{m} g h} \times 100\%$$

$$= \frac{(\frac{1}{2})(23)(23)}{9.8(65)} \times 100\%$$

$$= 42\%$$

---

(3)



$$\underset{\text{club}}{E_K} \rightarrow \underset{\text{ball}}{E_K}$$

$$\underline{65 J}$$

20% efficiency

$$\therefore \underset{\text{club}}{(0.20)(65)} = E_K \text{ ball}$$

$$13 = \frac{1}{2}(0.046)v^2$$

$$v = \sqrt{\frac{2 \times 13}{0.046}} = 24 \text{ m/s}$$

OR

$$\% \text{ efficiency} = \frac{E_{out}}{E_{in}} \times 100\%$$

$$20 = \frac{E_K \text{ ball}}{E_K \text{ club}} \times 100$$

$$20 = \frac{\frac{1}{2}(0.046)v^2}{65} \times 100$$

$$V = 24 \text{ m/s}$$

(6) Fossil Fuels take 100-600 million yrs. to form. That time frame is not considered "renewable".

renewable can be replaced as substance is being used. We will run out before new fuel is made.

(7)

Passive solar - building/landscape design so sun's radiant energy is maximized to heat building or (winter) minimized to reduce heating (summer)

heat/cool only

(*) Be familiar with design

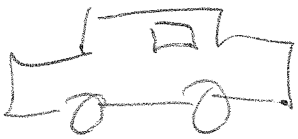
Photovoltaic cells - device used to convert $E_{light} \rightarrow E_{electrical}$.

Then we can use electrical energy for anything we want. Diverse

Extra Practice (Energy)

p. 232 1ab, 2
p. 235 #3, 4
p. 243 practice 1, 2

pg 232 #1a



$\Delta d = 82\,m$

$m = 1300\,kg$

$v_1 = 0 \longrightarrow v_2 = 14\,m/s$

a) $\Rightarrow W = ?$ $\boxed{W = \Delta E}$ Work/Energy theorem

$W = E_{k_2} - \cancel{E_{k_1}}^{0}$

$W = E_{k_2}$ $E_k = \frac{1}{2}mv^2$

$= \frac{1}{2}(1300)(14)(14)$

$= 127,400$

$= 1.27 \times 10^5\ J$

$(= 1.3 \times 10^3\ kJ)$

b) $F_{net} = ?$

$W = F_{net}d$

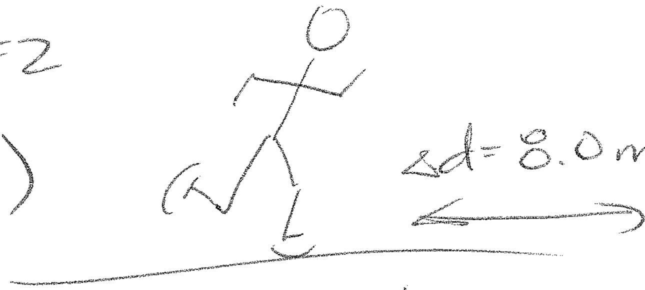
$F_{net} = \frac{1.3 \times 10^5\ J}{82\,m} = 1554$

$\boxed{F_{net} = 1.6 \times 10^3\ N}$

p. 232

#2

a)



$m = 52 kg$ $\quad V_2 = 0$

$V_1 = 11 m/s$

$F_{net} = ?$ assume only friction (turns his blades sideways)

- $F_{net} = ma$ → $v_2^2 = v_1^2 + 2ad$

$\cancel{v_2^2}^{0} = v_1^2 + 2ad$

$0 = (11)(11) + 2a(8)$

$\frac{-121}{16} = a$

$\underline{a = -7.56 \ m/s^2}$

- $F_{net} = ma$

$= (52)(-7.56)$

$= -393 \ N$ [fwd] $\quad F_{net} = 390 N$ [back]

b)

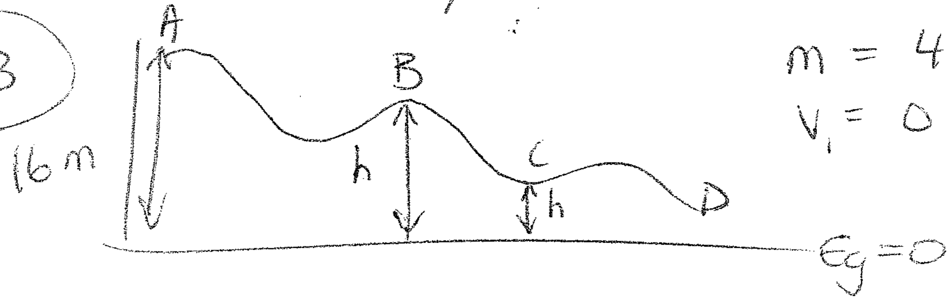
Work on skater is negative work ($-W$) for 2 reasons:

(1) $W = Fd$ and the force is backwards ($-F$)

(2) Skater is losing E_K ∴ $E_2 - E_1 < 0$ ∴ $\underline{-W}$

p. 235 - Energy

#3



$m = 42\,kg$
$v_i = 0\ m/s$ @ A

a) E_g @ A = ?

$E_g = mgh = (42)(9.8)(16) = 6586\,J$

$E_g = 6.6\ kJ$

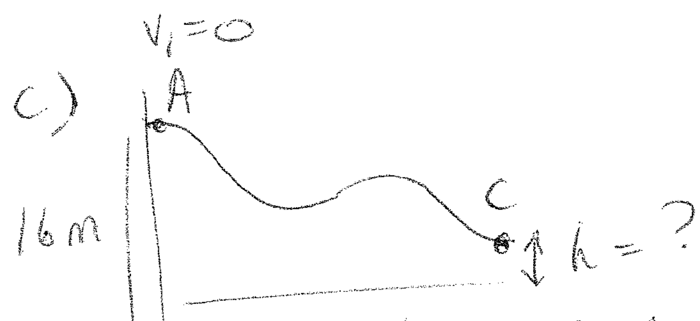
b) E_g @ B = 4500 J h = ?

$E_g = mgh$

$4500 = (42)(9.8)h$

$h = 10.9$ $h = 11\,m$ @ B

c)



loses 4900 J of E_g going A → C.

∴ loss $E_g = mg\Delta h$

$4900 = (42)(9.8)h$

$h = 12\,m$ lost

∴ 16 m − 12 m = 4 m
(A) (lost)

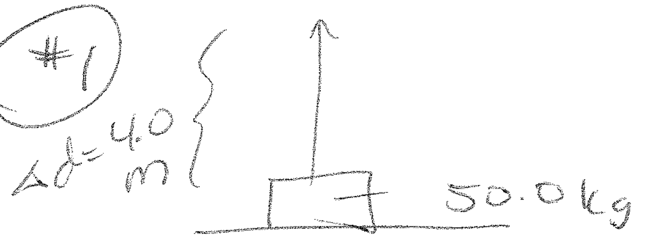
C is 4 m above ground

d) at ground level $E_g = 0\ J$

---

p. 243 Practice with Efficiency

#1



"uses 5200 J to lift"

$\therefore E_{IN} = 5200\ J$

$E_{out} = E_g @ 4.0\ m$

% eff = ?

$$\%\ \text{efficiency} = \frac{E_{out}}{E_{IN}} \times 100\%$$

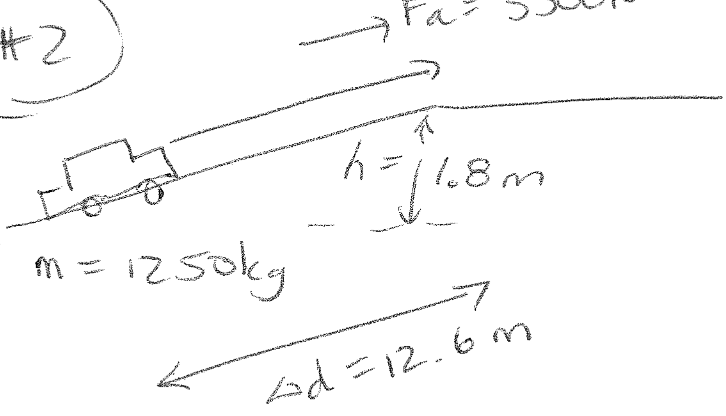
$$= \frac{mgh}{5200} \times 100\%$$

$$= \frac{(50)(9.8)(4)}{5200} \times 100\%$$

$$= 38\%$$

38% efficient

#2



a) useful E? = E_g

because you wanted car lifted up

useful $E = mgh$

$= (1250)(9.8)(1.8)$

$= 22050\ J = \underline{22\ kJ}$

b) E used to pull?

Can't directly tell the energy used to pull.
We do know Work done to pull

$W = Fd$

$= (5500)(12.6) = 69{,}300\ J$

Work transfers energy.
So 69,300 J of energy put in

(not all was used to change E_g.
not 100% efficient)

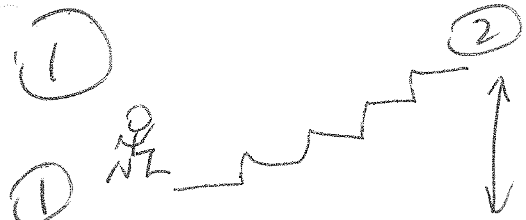
c) $\%\ \text{efficiency} = \dfrac{E_{out}}{E_{in}} \times 100\%$

$= \dfrac{22050\ J}{69300\ J} \times 100\%$

$= 32\%$

Don't use rounded numbers here

5.5 Power p. 254 #1, 2, 4



$\Delta h = 3.4 m$

$m = 54 kg$

$t = 32 s$

a) E_g at top? 2

$E_g = mg\Delta h$

$= (54)(9.8)(3.4)$

$= 1799.28$

$\underline{E_g = 1800 J}$

b) $P = ?$

$$P = \frac{\Delta E_g}{t} = \frac{E_{g_2} - E_{g_1}}{t}$$

$$= \frac{1799 - 0 J}{32 s} = \underline{56 \text{ Watts}}$$

c) A lighter person means mass is less.

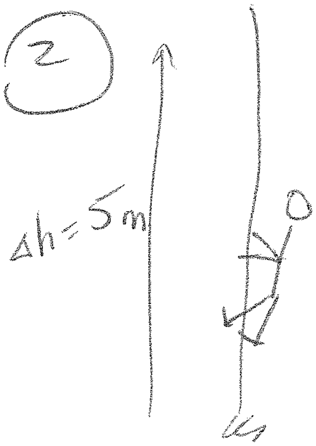
so $\underline{m} g \Delta h$ is smaller.

$$\frac{\text{small } E_g}{t} = \frac{\text{smaller}}{\text{power}}$$

* You can plugin real numbers if you wish.

ie lighter mass = 40kg + crunch numbers to show power now = $\underline{41 W}$

(2)



$m = 65$ kg

a) t to climb = ?

$$t = \frac{d}{v} = \frac{\Delta h}{v} = \frac{5.0\,m}{1.4}$$

$$\underline{t = 3.57\,s}$$

$v_{climb} = 1.4$ m/s

b) Power = ?

cannot use ~~time~~.

I wouldn't limit you. You could use time

$$P = \frac{\Delta E_g}{t} = \frac{E_{g_2} - E_{g_1}}{\frac{\Delta h}{v}} = \frac{mgh_2 - \cancel{mgh_1}^{\,0}}{\frac{5.0}{1.4}}$$

Can't use ∴ substitute

$$\frac{(65)(9.8)(5)}{5/1.4} = \underline{890 \text{ Watts}}$$

(4) 10 panels x 600W ⇒ P = 6000 W = 6 kW

a) $t = 4.5$ h each day

$$P = \frac{E}{t} \quad \therefore \quad E = Pt$$
$$= (6\text{ kW}) \times (4.5\text{h})$$
$$= \underline{27 \text{ kWh}} \text{ of energy}$$

each day produced by solar panels

b) cost = 5.5¢/kwh

so they will save in a year..

$$27 \frac{\cancel{kWh}}{\cancel{day}} \times \frac{365 \cancel{days}}{yr} \times \frac{5.5¢}{\cancel{kWh}}$$

$$= 54\,202.5¢ \div 100$$

$$= \$542.02$$

They will save ~ $540 each year.

(3)

$$1 \text{ kWh} = 1000 \text{ Wh} \quad (1 \text{ kW} = 1000 \text{ W})$$

$$1000 \text{ Wh} = 1000 \frac{J}{s} \cdot h \quad (1 \text{ W} = 1 \text{ J/s})$$

$$= 1000 \frac{J}{\cancel{s}} \times 3600 \cancel{s} \quad (1 \text{ h} = 3600 \text{ s})$$

$$= 3\,600\,000 \text{ J}$$

$$= \underline{3.6 \text{ MJ}}$$