Problem Set #2

4/14/15

1) a) USA: $\frac{\$50,500}{1 \text{ year}}\left(\frac{1}{2}\right) = \$25,250(x) = \$2,250,000$ **x = 90 people**

China: $\frac{\$6,800}{1 \text{ year}}\left(\frac{1}{2}\right) = \$3,400(x) = \$2,250,000$ **x = 662 people**

Guatemala: $\frac{\$2,740}{1 \text{ year}}\left(\frac{1}{2}\right) = \$1,370(x) = \$2,250,000$ **x = 1,643 people**

DR Congo: $\frac{\$231}{1 \text{ year}}\left(\frac{1}{2}\right) = \$115.50(x) = \$2,250,000$ **x = 19,481 people**

b) Affording a Veyron (using data from statista.com)

USA: **62,859 people** [ultra high net worth individuals]
62,859/318,900,000 = **0.02% of population**

China: **7,631 people**
7,631/1,357,000,000 people = **0.0006%**

Guatemala: **245 people**
245/15,470,000 = **0.002%**

DR Congo: 1,024 in all of Africa (pop: 1,111,000,000)
~**62** in Congo (pop: 67,510,000)
62/67,510,000 = **0.00009%**

☆ Note: data used defines UHNWI as $50 million or more, so % might be lower than if $30 million was used ☆

2)

10'

$W = \frac{F \cdot d}{T}$

10' ~ 3 m

Time = 3.8 seconds

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

$U = mgh$ $\frac{\approx 60\,kg\,(10\,m/s^2)\,3m}{3.8\,s} \approx \frac{600\,kg\,m/s^2}{s} = 600\,W$

3.8 ~ 3

3) 1. Four Stroke Engine

Petroleum + Heat => [engine] => waste heat + work

[tank] [spark plug]

2. Steam Locomotive Engine

Fuel + Heat => [engine] => steam pushes piston => waste heat + work

[wood, oil coal] [burning]

3. CO_2 Motor

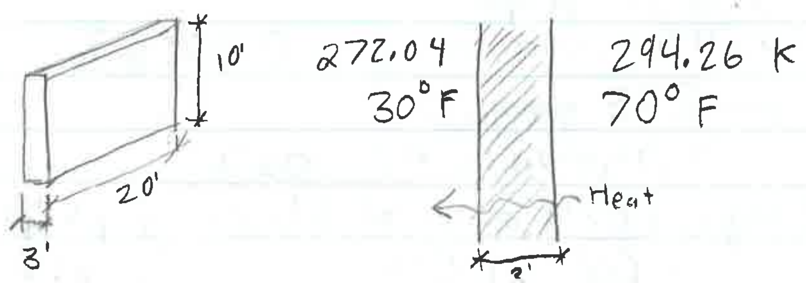
CO_2 liquid + Piston motion => [engine] => CO_2 steam pushes piston -> propeller / flywheel motion

4. Jet Propulsion: Turbo fan

Air + Combustion => propulsion

\+ Air turns fan, additional thrust provided

4)



a) Temperature gradient: $\Delta T = 22.2$ K 22.2 K / 0.9144 m **= 24.3 K/m**

b) Rate of heat loss:

$H_t = U\ A\ dt$

("U" value)(area)(temperature difference)

$H_t = 0.1\ (200\ ft^2)(40°)$

Internet way: **H_t = 888.8 Btu/hr => 260.4 W**

Adobe R value = 0.25 per inch

0.25 (36 in) = 9

$U = \frac{1}{R}$ U = 0.1

Video way:

$\frac{1\ btu}{1\ hr} = 0.293$ watts

$0.57 \frac{W}{m \cdot K} (18.58 m^2)(24.3 \frac{K}{m})\ \frac{W}{m \cdot K}\ (m)^2 \left(\frac{K}{m}\right) =$ **257 W** $=> \frac{3.412\ BTU/hr}{1\ W} =$ **878.1 BTU/hr**

Problem Set #2

① a) Base Price = \$1,700,000

How many years would it take someone to buy this car in:

USA = \$44,888 × ½ = \$22,000 saved/person

$\frac{1,700,000}{22,000}$ ≈ 78 people

China = \$7,663 × ½ = 23,750 saved/person.

$\frac{1,700,000}{7,663.30}$ ≈ 222 people

Guatemala = 1,600 × ½ = 800 saved/person

$\frac{1,700,000}{800}$ = 2,125 people.

DR congo = \$120 × ½ = 60 saved/person

$\frac{1,700,000}{60}$ ≈ 28,334 people.

b) How many ultra millionaires can by this car?

USA = 309,975,000 total population

= $\frac{65,905 \text{ ultra millionaires}}{309,975,000 \text{ people}}$ ≈ .02% Ultra millionaires

sources: worldatlas.com, wealthx.com

China ⇒ total population: 1,339,190,000

= $\frac{10,675 \text{ U.M.}}{1,339,190,000}$ ≈ 8×10^{-4}%

sources: worldatlas.com, wealthx.com

Guatemala ⇒ total population: 15.47 million

= $\frac{245 \text{ U.M.}}{15,470,000}$ = 1.5×10^{-3}%

sources: worldatlas.com, wealthx.com

DR Congo ⇒ total population: 67.51 million

= $\frac{1}{67,510,000}$ = 1.5×10^{-6}%

2. First way: Kinetic energy: pushing someone on a bicycle.

$P = \frac{F \cdot d}{time} = \frac{180N \times 12m}{3.61s} = 598\, W \left(\frac{J}{S}\right) \times \frac{1\, BTU}{1055\, J} \approx .6\, \frac{BTU}{S} \times \frac{3600S}{hr} \approx 2100\, \frac{BTU}{hr}$

$598\, W \times \frac{1\, Horsepower}{754\, W} \approx .01$ Horsepower. I would be able to keep this energy going for about 4 more seconds.

Second way: Running up stairs. Potential Energy .

well? get running! $\Delta PE = mg\Delta h$

$Power = \frac{\Delta E}{\Delta t}$?

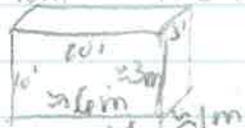
3. ① Gnome Rotary Engine:
we put work in by opening the valve and allowing air and fuel to go in towards the top of the machine but not dead center. we also do work compressing the gas inside the ~~[illegible]~~ cylinder. The engine does work for us when we light the fuel on fire and it starts into rotation emitting exhaust as it turns. The extra energy comes from the combustion of fuel.

② Coomber Rotary Engine: we put work into the engine by blowing steam under the rotating bar as it goes up the eclipse shape. As we put work in, the motor squeezes the gas as it moves. The engine does work for us as soon as it passes vertical because it's kinetic energy turns into gravitational energy. The extra energy that comes from the engine comes from the combustion of fuel from the sparkplug as the wheel rotates.

③ Watt Beam Engine: we put work into the engine by starting the rotational process of the wheel. As we put work in, the engine takes our work and compresses the gas in the ~~valve~~ chamber (cylinder). However, the compressed gas-fuel mixture gets combusted by the spark plug and releases energy & heat.

④ Two cylinder Stirling Engine: we put work into the system by compressing the cold molecules pushing them towards the hot section. In the hot section the gas expands; therefore, the gas does the work for us. $W_{out} > W_{in}$ because we add heat to the system to expand the molecules.

4.



$K = .57\, \frac{W}{mK}$

$70°F \approx 21°C + 273 = 294K$

$30°F \approx -7°C + 273 = 272K$

$P = KA\frac{\Delta T}{\Delta \ell}$

$= (.57\, \frac{W}{mK})(3m \times 6m)\left(\frac{294K - 272K}{1m}\right)$

$= (.57\, \frac{W}{K})(18m^2)\left(\frac{22}{1m}\right)$

$= .57\, W\, (400)$

$\approx 225\, W$

$225\, W = \frac{J}{S}$

$225\, \frac{J}{S} \times \frac{1\, BTU}{1055\, J} \approx .25\, \frac{BTU}{S}$

$.25 \times \frac{BTU}{S} \times \frac{3600S}{1hr} \approx 900\, \frac{BTU}{hr}$