PS #4

1a Average distance ~ 13,000 miles $= 1.3\times10^{4}$ mi

Average Mileage ~ 25 MPG

~~drivers~~ people ~ 300 million $= 3\times10^{8}$

Total use: $\frac{1.3\times10^{4}\ \text{mi/person}\ \cdot\ 2\times10^{8}\ \text{person}}{25\ \text{mi/Gal}} \approx 10^{11}\ \frac{\text{Gal}}{\text{year}}$

$= 10^{11}\ \frac{\text{Gal}}{\text{year}}\ \frac{\text{Barrel}}{42\ \text{Gallons}} \approx 2\times10^{9}\ \frac{\text{Barrel}}{\text{year}}$

1b ~ 37% of $\underbrace{10^{20}\ \text{J}}_{\text{US Total energy}} = 3.7\times10^{19}\ \text{J}\ \frac{\text{Gal}}{120\ \text{MJ}}\ \frac{\text{Barrel}}{42\ \text{Gal}}$ (10^{13}; $120\ \text{MJ}\ 42\ \text{Gal} \sim 5\times10^{3}$)

$\sim 6\times10^{9}$ Barrel

1c if US uses $\frac{1}{5}$ of world's Petroleum,

world's use is ~ 3×10^{10} Barrels, or 30 Billion Barrels

1d) US EIA - 18.5 $\frac{\text{M bbl}}{\text{day}} \cdot 360\ \frac{\text{day}}{\text{yr}} = \frac{6.6\ \text{Billion Barrels}}{\text{year}}$

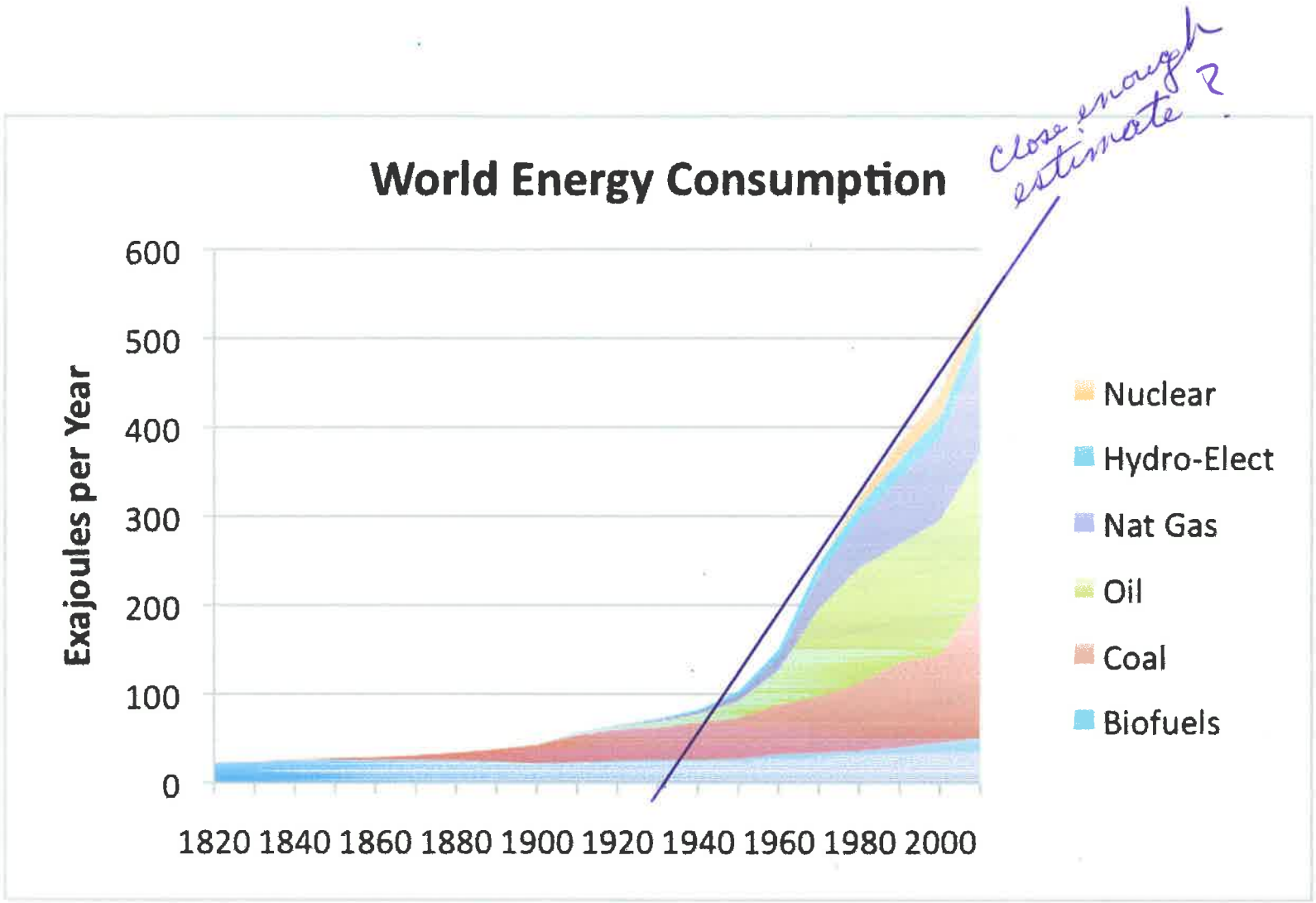
World - 91 $\frac{\text{M bbl}}{\text{day}} \cdot 360\ \frac{\text{day}}{\text{yr}} = \frac{32\ \text{Billion Barrel}}{\text{year}}$

$= \frac{32\times10^{9}\ \text{Barrel}}{3.14\times10^{7}\ \text{s}} \cdot \frac{42\ \text{Gal}}{\text{Barrel}} \cdot \frac{120\ \text{MJ}}{\text{Gal}} \approx \boxed{5.3\ \text{TW}}$

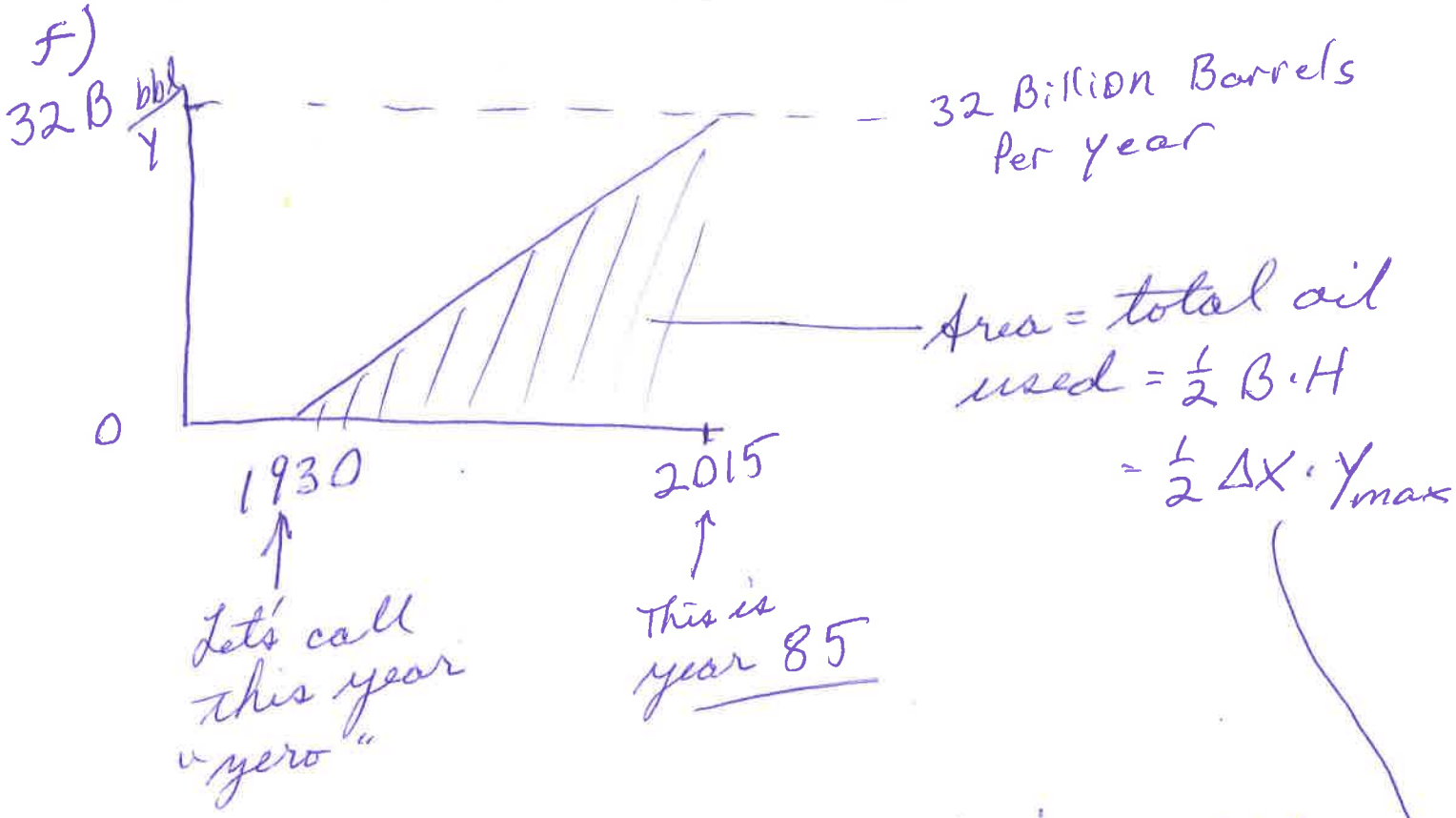
Like in Energy Flow graphic from week 1

1e) Trillion $\approx 10^{12}$ time $= \frac{\text{Oil}}{\text{Use rate}}$

$= \frac{10^{12}\ \text{bbl}}{32\times10^{9}\ \frac{\text{bbl}}{\text{yr}}} \approx 30$ years


World Energy Consumption
Exajoules per Year
600
500
400
300
200
100
0
1820 1840 1860 1880 1900 1920 1940 1960 1980 2000
Nuclear
Hydro-Elect
Nat Gas
Oil
Coal
Biofuels
close enough estimate ?

f)



The amount of oil we use per year

$$= \frac{32 \text{ Billion Barrels}}{\text{Year} \cdot 85 \text{ years}} \left(\begin{array}{c}\#\text{ of year} \\ \text{in our new scale}\end{array}\right)$$

$$\text{Total oil used} = \frac{1}{2}(\#\text{ years}) \cdot \frac{32\times10^9 \text{ Barrel}}{\text{year}\,(85\text{yr})}(\#\text{ years})$$

$$= \frac{1}{2}\left(\frac{32\times10^9 \text{ Barrel}}{85\ (\text{yr})^2}\right)(\#\text{ years})^2$$

$$= \frac{0.19\times10^9 \text{ Barrel}}{(\text{yr})^2}(\#\text{ years})^2 = \frac{1.9\times10^8 \text{ Barrel}}{(\text{yr})^2}(\#\text{ yrs})^2$$

assuming the total amount is 2 Trillion.

g) $2\cdot10^{12}$ Barrels $= \frac{1.9\times10^8 \text{ Barrel}}{(\text{yr})^2}(\#\text{ yrs})^2$

$$\#\text{ yrs} = \left[\frac{2\times10^{12} \text{ Barrels}}{1.9\times10^8 \text{ Barrel/(yr)}^2}\right]^{\frac{1}{2}} \approx 100 \text{ yrs}$$

$- 85$ yrs so far

Pete's Rounding errors: correct answer ≈ (25 yr) ~~15 yrs~~ more!

h) Total oil = 110 ZJ = 110×10^{21} J = 1.1×10^{23} J

$$\left(1.1\times10^{23}\,\text{J}\right)\left(\frac{\text{Gallon}}{120\times10^{6}\,\text{J}}\right)\left(\frac{\text{Barrel}}{42\,\text{Gallon}}\right) \approx 2\times10^{13}$$

$= 20$ Trillion Barrels!!!

But it's not all accessible,

but if it were all accessible,

i) assuming we continue using 32 B barrels a year:

$$\#\,\text{yrs} = \frac{20\times10^{12}\,\text{Barrels}}{32\times10^{9}\,\text{Barrels/yr}} \approx .6\times10^{3} = 600\,\text{yrs}$$

assuming continued linear increase from part g):

$$\#\,\text{yrs} = \left[\frac{21\times10^{12}\,\text{Barrels}}{1.9\times10^{8}\,\text{Barrels/yr}^2}\right]^{\frac{1}{2}} = 330\,\text{yrs}$$

$- 85$ yrs so far

~ 250 yrs more.

but again, it's not all accessible.