100 pts, $n = 23$, $\langle\ \rangle = \overset{61}{\cancel{}}$, $\sigma = 21.2$ ☺

DH-1) Two-cat fighting: Humans produce about 100 W-thermal, assume two big fighting cats produce 30 Wt,. [1 kW = 3412 BTU/hour]. DH dream house is a cube, 10 feet on a side, raised on stilts, so 5 surfaces are the same, and one is glass. R30 walls and R5 glass (quality + draped cover)

a) What is the amount of free temperature my cats obtain, with no other heat inputs.
b) If I set the thermostat at 68F, what temperature outside will turn the thermostat on?
c) This house (without the cats or people) is placed in Minneapolis with 8000 F-degree days. How many barrels of oil (5.8 M BTU/bbl) are consumed in the year.?
d) Very approximately, how much heat is needed to heat the house when I move in with the cats (120 Wt + 100 W electronics and lights= 220 Wt total), what is my annual heating bill. (make reasonable assumptions)
e) How much is my heating bill if I capture 50% of the solar flux over three months at Winter solstice, at 45 degrees latitude, and 10 hour days, (T=20 h) S = (434 BTU/ft2-h) exp(-1/3 cosθ)

a)

$$\sum U_i A_i = (5)(100)/30 + (100)(1/5)$$
$$17 + 20 = 37$$

$$\boxed{\Delta T} = \frac{\dot{Q}}{\sum U_i A_i} = \frac{(0.03)(3412)}{37} = \frac{102}{37} \boxed{= 2.8 \\ = 3\,°F}$$

b) Balance Temp $= 68 - 3 = \boxed{65\,°F}$

c) $\dot{Q} = \sum U_i A_i \Delta T$, $Q/_{yr} = \sum U_i A_i\, d\theta \times 24h = (37)(8000)(24)$

$$= \boxed{7.1\ \frac{MBTU}{y}} \left(\frac{1\ bbl}{5.8\ MBTU}\right) = \boxed{1.2\ \frac{bbl}{y}}$$

d) $\dot{Q} = 20 + 100 + 100 = 220W\left(\frac{3412}{1000W}\right) = 750\ BTU/h$

over 4 Months $Q = (750\ BTU/h)(120\ d)\left(\frac{24h}{d}\right) = 2.2\ M\ BTU$

$$Q_{\overset{\text{with}}{\text{int heat}}} = 7.1 - 2.2 = \boxed{4.9\ MBT \\ = 0.8\ bbl/y}$$

bbl = \$100
\$80

e) $S = (434)\, e^{-\frac{1}{3\cos\theta}}$

$\theta_{Dec\ Solstice} = 23 + 45 = 68°$

$\angle\theta$ $S_0 = 434\, e^{-\frac{1}{3\cos 68°}} = (434)(0.41) = 178\ \frac{BTU}{ft^2\text{-}h}$

A Net Gainer!

$S_{vert} = \sin 68°\, S_0 = (.93)(178) = 165\ \frac{BTU}{ft^2\text{-}h}$

$I = \frac{T\,S_v}{\pi} = \frac{20}{\pi}(165) = \frac{1050}{day}$, $\frac{I}{2} = 525$ total $A(120\ d)\frac{I}{2} = (525)(100\ ft^2)(120\ days)$

$= 6.3\ MBTU$

DH-2) passively safe reactors

a) Scaling: Why might smaller power level reactors be safer, when considering heat transfer vs. heat generation, use an equation to convince me.
b) Why is scaling not as useful as we would like? Think time constants.
c) Why is power generation proportional to time to the –0.3 power ($t^{-0.3}$) more difficult than time to the –3 power (t^{-3})
d) Adding more thermal mass can help: compare the thermal inertia of 100 tonnes of UO2 and 100 tonnes of graphite. But why would this innovation be of limited efficacy?
e) Molten Salt reactors can be shut down without cooling power without an immediate problem, how come?

a) $\dot{Q}_{Loss} = (4\pi R^2)\left(\frac{U}{\cancel{R}}\right)\Delta T = \dot{Q}_{Gain} = \frac{4}{3}\pi R^3(\alpha)$

This is steady state
Not transient

given $\Delta T = R\left(\frac{\alpha}{3U}\right)$ prop to size

$\alpha = \frac{\dot{Q}_{Gain}}{Volume} = const$

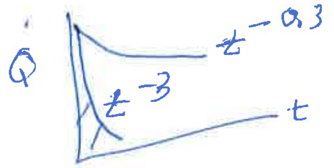
Make smaller helps .... but

b) one minute rise time doesn't effect outside, Temp, the Reactor to work will heat as before if not much exit heat loss

c) heat pulse keesgoing too much, let $t = 100\,s$, $10^4 s$

	$t^{-0.3}$	t^{-3}
100	0.25	10^{-6}
10^4	0.063	10^{-12}

!



$t^{-0.3} \sim \frac{1}{\sqrt{t}} = t^{-0.5}$

Not a pulse!!

d) $\Delta Q_{\text{to danger}} = NC\Delta T$

UO_2, $N = \frac{10^5\,kg}{238+32} = 370$ moles

C, $= \frac{10^5}{12} = 8330$ moles

Ratio $\frac{N_C}{N_{UO_2}} = \frac{8330}{370} = 23$ times more moles

e) Liquid heats up, but a long way from NaCl Vapor