ASSIGNMENT ONE

(due Friday 3 October at Farquharson 229 before 5:00 PM)

Question One. *Radiative Balance*

(Per student vote.) Compare the radiative balance of a cold-blooded reptile and a warm-blooded mammal (select examples that are similar in size).

Determine their surface area, specific and total metabolic rate at rest, and the impact of radiative heat loss on their body temperature. Make sure you cite any references you use in a way that will make it possible for your professor to find the reference easily. Please ensure you show units!

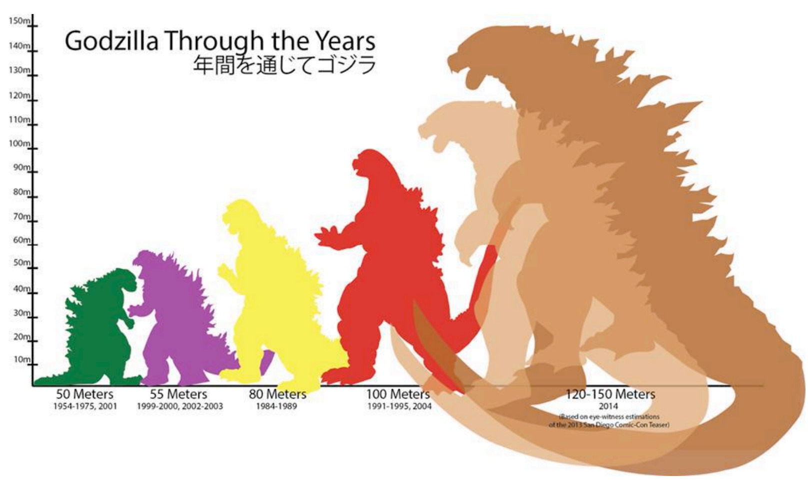
Hints and facts that you may (or may not) find useful...

• Take a look at your course notes related to radiative heat emission. For $T_{ambient}$, the T_{sky} is usually used, about –20 Celsius).

• You will need to search the literature for caloric requirements of the examples you choose, and may have to make an informed estimate of their size and surface area.

Question Two. *Galileo scaling and the strength of biomaterials*

Over fifty years, Godzilla has rapidly increased in size at an astonishing rate. Would it work? Explain clearly with suitable quantitative analysis. Assume the tail is not load-bearing.



Guidelines

I expect that students may wish to work together on the assignment, that is fine, but be sure that your assignment is in your own words. Remember that you have to explain your answers with sufficient clarity, so that a non-physicist like Dr. Lew will understand them. He often finds diagrams helpful and is obsessed with ensuring that the units work, so showing the units is obligatory. Excessive length is not encouraged.

Question One: Comparative radiative balence of reptiles and mammals

Heat production due to metabolism is --in part-- offfset by radiative heat loss.

Students selected a diversity of reptiles and mammals to compare. Basal metabolic rates were either obtained as experimental measurements or estimated from some form of BMR α M^x where M is the mass and x is a best-fit, usually about 0.7. A more accurate formula ($BMR=kM^x$) accounts for the shift in the y-axis intercept (k).

Points were lost if students claimed mammals and reptiles have the same BMR. They don't.

On average, reptiles have a lower BMR: about 10-40% that of an equivalent sized mammal. Some students expressed the heat production as increased T over time.

Radiative heat emission is described by:

$$P_{new} = \sigma \cdot \varepsilon \cdot A(T_{body}^4 - T_{ambient}^4)$$

Some students used conductive heat loss, but if so, needed to account for 'furry' mammals and 'naked reptiles.

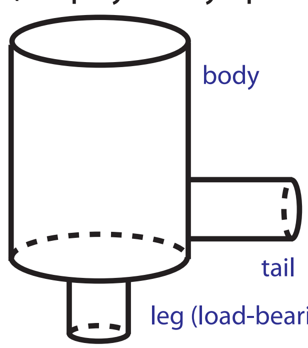
Partial points were lost for a conductive model.

The answers ranged, dependent on other factors. For example, if a reptile is at the ambient temperature, it won't have a net loss. In fact, $T_{ambient}$ if often considered to be T_{sky} (–20 Celsius). Basking in the sun or shade is an ideal (low metabolism) way for a repitle to control T_{body}.

Points were awarded for clarity and sophistication of analysis.

Question Two: Does a larger Godzilla work? (biophysically speaking?)

Probably the best approach that students used was a cylindrial model



Many opted for a compressive failure (compressive failure = ρh), but we already know that it doesn't provide a helpful answer for a tree. Euler's column is more realistic.

Points were deducted dependent on how much effort was made.

$$F_{critical} = \frac{E \frac{\pi r^2}{4} \pi^2}{h^2}$$

Note that it is not $(2h)^2$ because the leg column is not anchored like a tree

For compressive failure, Godzilla can be very tall, For columnar buckling, no, Godzilla would not work.

Some students were aware that static load and live load should be considered (especially if you are an engineer).

Points awarded

The 'correct' answer is likely to be that the leg diameter of a tall Godzilla must increase dispro-portionately for a large Godzilla to work (rather than crumple).