EOSC 340 Assignment 1

This assignment has two parts. First, we're asking you to work with a followup stock and flow question. Second, we're asking you to read some climate information from the internet and evaluate it.

As with the pre-class quiz questions, do all the work and get all your answers before you go into Connect to enter them.

Stock and Flow Followup:

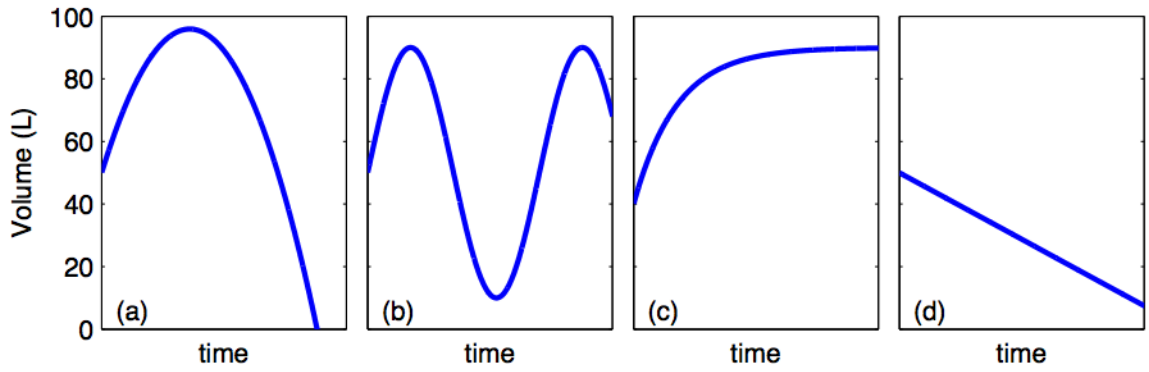
Consider a straight-sided bathtub with inflow and outflow rates changing over time such that the inflow decreases at a constant rate and the outflow increases at a constant rate. These flow rates can be written:

$I_{in}(t) = 20 - at$ [litres/min]

$I_{out}(t) = 5 + bt$ [litres/min]

where a and b are positive constants. The initial volume is 50 L.

1. Form the stock and flow equation for this problem. Use this to decide which of the following figures **best** describes the volume in the bathtub as a function of time.



Solution: *first simplify the equation –*

$$\frac{dV}{dt} = I_{in} - I_{out}$$
$$= 20 - at - (5 + bt) \qquad (1)$$
$$= 15 - (a + b)t$$

Equation (1) shows that at t=0 the volume is growing, but because (a+b)>0 you know that the fill rate is slowing. Integrating (1) with respect to time gives:

$$V = V_0 + 15t - \frac{a+b}{2}t^2 \qquad (2)$$

Where V(0)=50 l means that V_0=50. So you know it's a parabola, and it's got to be pointing down since V grows slower and slower before falling as time increases.

Answer: (a)

2. At what time does the water level reach its maximum value? Assume *a* and *b* are such that the tub does not overflow. All times are given in minutes.
    a. 0
    b. $(a + b)^2$
    c. 15 * (a + b)
    d. 15 / (a + b)
    e. 20a - 5b

    Solution: The maximum occurs when dV/dt=0, which from Equation (1) is:

$$t_{max} = \frac{15}{a+b} \tag{3}$$

    Answer: (c)
3. If the volume of the tub is 100 L, what condition must be satisfied so that the tub never overflows? *Hint: First integrate the stock and flow equation to derive the function V(t). You will need to use the initial condition to evaluate the integration constant.*
    a. $(a + b) \geq 1.25$
    b. $(a + b) \geq 2.25$
    c. $(a + b) \geq 5.00$
    d. $(a + b) \geq 7.25$

    Solution*: We want the maximum volume to be V=100, so insert* t_{max} *into Equation (2)*

$$100 = 50 + 15t_{max} - \frac{a+b}{2} t_{max}^{\ 2} \tag{4}$$

    Putting $t_{max}=15/(a+b)$ *into (4) and simplifying gives (a+b)=2.25 exactly. So whatever the value of a and b, we know that as long as their sum is bigger than 2.25 we are safe from overflowing and the answer is (b).*

    Answer (b)

Blackbody Radiation:

Imagine yourself living in a different solar system, learning about your sun. You measure the blackbody spectrum of your sun, and so you know its temperature is *T*. Furthermore, your astronomers tell you the sun has a radius *R*.

4. How would you calculate the power output [Watts] of this sun? *Hint: Think about your units.*
    a. $P = \sigma(RT)^4$
    b. $P = \sigma T^4 \, 4\pi R^2$
    c. $P = \sigma T^4 / (4\pi R^2)$
    d. $P = \sigma T^4 \, (4/3)\pi R^3$
    e. $P = 3\sigma T^4 / (4\pi R^3)$

Solution: *Calculate the irradiance* $[W/m^2]$ *using Stefan-Boltzman:* $I = \sigma T^4$

Then recognize that you just have to multiply by the area of the sun to get the total power

$P = I\,A = \sigma T^4\, 4\pi R^2$

5. If a solar catastrophe suddenly caused your sun to collapse to half its radius, but the power output stayed the same, what would be the new temperature T^* of your sun?

a. $T^* = 2T$
b. $T^* = 2^2\,T$
c. $T^* = 2^4\,T$
d. $T^* = 2^{1/2}\,T$
e. $T^* = 2^{1/4}\,T$

Solution: *Rewrite your solution from the previous question as*

$T^4 = P/\sigma 4\,\pi R^2$

This can be written simply as

$T^2 = C/R$

where C is just a constant: $(P/\sigma 4\pi)^{1/2}$

if you let R go to R/2 you get

$T^{*2} = 2C/R$

$T^{*2} = 2T$

$T^* = 2^{1/2}T$

Sea Level Rise:

- Read this short 2010 commentary on sea-level rise: http://www.nature.com/climate/2010/1004/full/climate.2010.30.html
- Read this Georgia Straight article from March 29th, 2017: https://www.straight.com/news/887396/climate-change-rising-sea-levels-and-location-new-st-pauls-hospital-vancouver

6. According to Lowe and Gregory (2010) how much sea level rise does the IPCC (2007) estimate will occur by 2100? Choose the closest answer.

a. 15 cm
b. 40 cm
c. 1 m
d. 2 m
e. 10 m

7. Lowe and Gregory (2010) state that certain Greenland and Antarctica glaciers have sped up and are discharging more ice into the sea than in previous decades. What evidence do they cite to support this claim?

a. Higher than predicted sea level rise
b. Isotope measurements
c. Observations of icebergs calving off the glaciers
d. Satellite observations
e. Modelling

8. In Lowe and Gregory (2010) two ways of determining sea level rise are discussed. What is the difference between the "semi-empirical" methods used to estimate future sea level rise described by Lowe and Gregory (2010) and the approach used by the IPCC (2007). Explain in a sentence or two.

   The semi-empirical approach estimates future sea level rise based on historical relationships between sea level rise, temperature, and radiative forcing, making an assumption that these relationships can be extrapolated into the future. In contrast, the IPCC (2007) approach is to model the various physical processes that cause sea level to rise (like thermal expansion and melting land ice – though in 2007 they didn't have good understanding of the land ice melting piece, so they didn't include possible future acceleration of land ice melting) and add them up.

   2 pt: clear difference between the two, including that semi-empirical is based on observed relationships, rather than trying to model physical processes.
   0.5-1.5 pt: one was clear, but not both, or not clearly differentiated. Missed modelling aspect of IPCC method - only included "summed up processes"
   0 pt: not answered, or no explanation of the approaches. Doesn't answer the question. (DS: copied and pasted quotes from the article)

9. What is the 2100 sea level rise estimate according to the semi-empirical approach? How does this compare to the IPCC (2007) estimate? Compare the two estimates in one sentence.

The semi-empirical approach yields higher estimates (1-2 m by 2100) of future sea level rise than the IPCC estimates (0.26-0.59 m increase by the 2090s).

1 pt: has both estimates and they're approx. right.
0.5 pt: has one of the estimates right. Or if they reversed them. (DS: OR only provided one set of numbers OR said one was higher than the other without providing numbers)
0 pt: wrong estimates, not answered

10. Vancouver is a city quite close to sea level. According the to the Georgia Strait article, what areas of the city are most at risk of flooding given a 4 meter sea level rise? [0.5 pts]

    a. UBC
    b. False Creek
    c. Southwest Vancouver
    d. North Vancouver
    e. b and c

11. If you were engaged in the Vancouver city planning process, in addition to improving building design for flood resilience, what other city infrastructure would you want to focus on and why? (two sentences)

2 pt: Identify infrastructure – roads, transport, parks, schools etc and a reasonable why
1.5 pt: Link between infrastructure and why is unclear
1 pt: missing one or the other parts
0.5 pt: very weak (but not totally improbably) answer
0 pt: none make sense.

12. How much time did you spend on this assignment? Please enter a number in units of hours. Decimals are OK. (i.e. 1.5). Please enter just a number in the quiz. You don't need to write the word *"hours"*.