CPIB SUMMER SCHOOL 2010: INTRODUCTION TO BIOLOGICAL MODELLING

Introductory Quiz (Unassessed) September 2010

This quiz is purely for information, to help tailor the course to the audience. It will be most informative if you attempt the questions on your own, and try questions 9–12 without using a computer or graphing calculator. Please fill in your answers at
http://www.maths.nottingham.ac.uk/mathsforlife/intro_quiz.html

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Your background

1. What is your mathematical background?
   (GCSE? A-Level? Undergraduate courses taken, if any?)
2. Describe your scientific background.
3. Briefly describe your experience, if any, of mathematical modelling and/or systems approaches to biomedical science.

Algebra: important for writing and understanding models, finding steady states, and various kinds of model analysis.

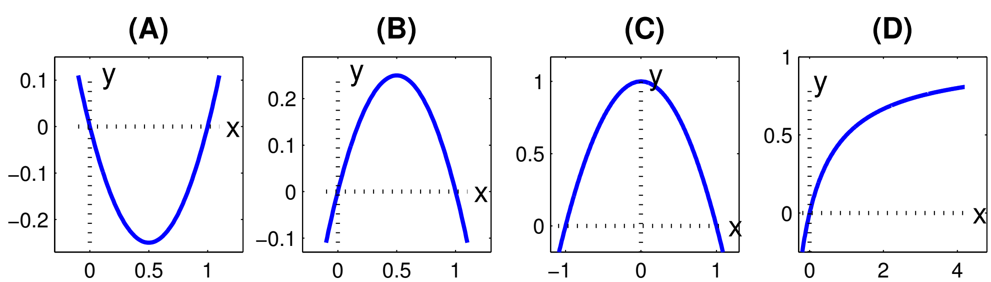
4. Written as a single power, x^7/x^2 equals:
   A: x^9, **B:** x^5, **C:** x^{-5}, **D:** x^{14}.
5. Written as a single logarithm, $\log(a) + \log(b)$ equals:
   A: a/b, **B:** $\log(a/b)$, **C:** $\log(ab)$, **D:** $\log(a^b)$.
6. What is the solution to the equation $4x + 3 = 2x + 5$?
   A: $x = 0$, **B:** $x = 1$, **C:** $x = 2$, **D:** $x = 3$,
7. What are the two solutions to the quadratic equation $x^2 + 3x + 2 = 0$?
   A: $x = 1, 2$, **B:** $x = -1, -2$, **C:** $x = 2, 3$, **D:** $x = -1, 2$.
8. What is the solution to the following pair of simultaneous equations?

$$\begin{aligned} x + 2y &= 3 \\ 2x - y &= 1 \end{aligned}$$

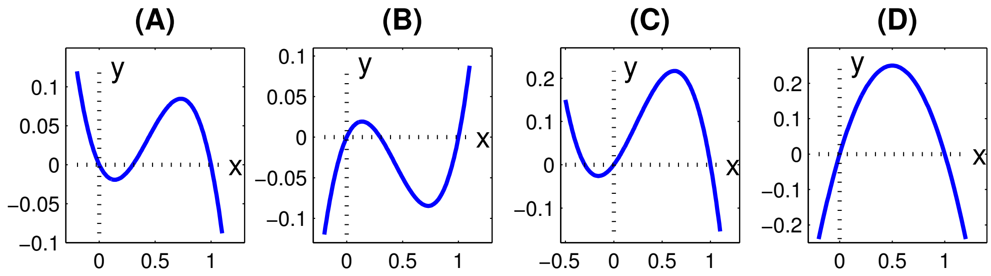
   A: $x = 2, y = 2$, **B:** $x = 3, y = 1$, **C:** $x = 1, y = 3$, **D:** $x = 1, y = 1$.

Sketching graphs: essential for qualitative model analysis.

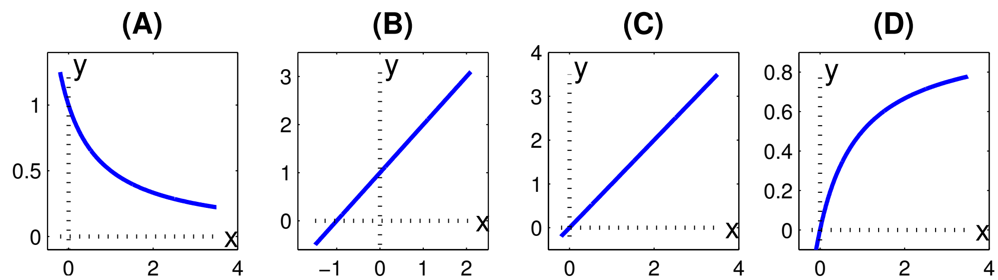
9. Which is the correct graph of $y = x(1 - x)$?



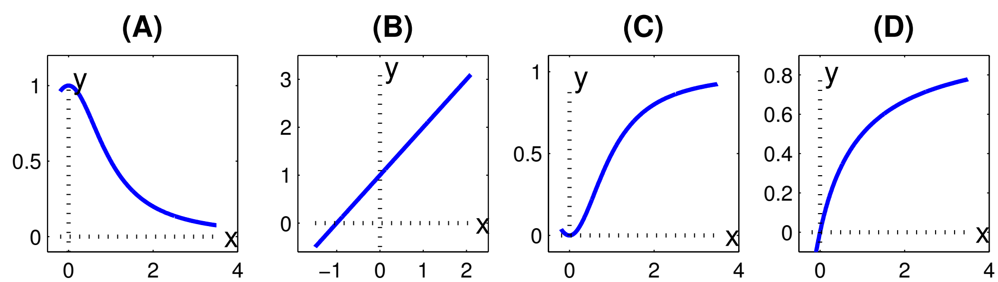
10. Which is the correct graph of $y = x(1-x)(x-0.25)$?



11. Which is the correct graph of $y = \frac{x}{1+x}$?



12. Which is the correct graph of $y = \frac{x^2}{1+x^2}$?



Differentiation: useful for sketching graphs (finding slopes, maxima and minima) and linear stability analysis of model steady states.

13. Differentiating $y = 2x^3 - 3x^2 - 12x + 4$ gives

    A: $\frac{dy}{dx} = 6x^2 - 6x - 12$, **B:** $\frac{dy}{dx} = 2x^4 - 3x^3 - 12x^2 + 4x$, **C:** $\frac{dy}{dx} = 2x^2 - 3x - 12$, **D:** $\frac{dy}{dx} = 6x^2$.

14. Differentiating $y = \frac{x^2}{1+x^2}$ gives

    A: $\frac{dy}{dx} = \frac{2x}{1+x^2}$, **B:** $\frac{dy}{dx} = 2x - (1+x^2)$, **C:** $\frac{dy}{dx} = \frac{2x}{(1+x^2)^2}$, **D:** $\frac{dy}{dx} = 2x(1+x^2) + 2x^3$.

Exponential growth: solves the most fundamental differential equation.

15. The population of an organism, x, obeys an exponential law of the form $x = Ae^{kt}$,
    where t is a variable, and A and k are constants.
    If $x = 2$ when $t = 0$, and $x = 8$ when $t = 2$, what are the values of A and k?

    A: $A = 2, k = 2$, **B:** $A = 1, k = 1$, **C:** $A = 2, k = \ln(2)$, **D:** $A = 1, k = 2\ln(2)$.

16. What is the solution to the Ordinary Differential Equation: $\frac{du}{dt} = \lambda u$ with $u(0) = A$?

    A: $u(t) = Ae^{\lambda t}$, **B:** $u(t) = \lambda t + A$, **C:** $u(t) = \lambda$, **D:** $u(t) = u + \lambda$.

Markus Owen, August 2010.