SCI 1199 (Spring 2013)

Homework 2

Do the following warmups and problems. Submit your answers, including the short explanation, online by ***8pm on Tuesday, 11 Mar 2013****—see* **sanjoymahajan.org/courses/waves/**

Open universe: *Collaboration, notes, and other sources of information are* ***encouraged.*** *However, avoid looking up answers to the problem, or to subproblems, until you solve the problem or have tried hard. This policy helps you learn the most from the problems.*

Homework is graded with a light touch: P (made a decent effort), D (made an indecent effort), or F (did not make an effort).

In the following questions, you are often asked to give your answer as a plausible range. For most of the questions, it is the exponent x in 10^x that you are asked for. You can specify 10^x as $10^{a\pm b}$ or as $10^{c\ldots d}$ (where $c = a - b$ and $d = a + b$). Think of b as the sigma (σ) measuring your uncertainty, or $c \ldots d$ as the one-σ range. Use the format that easier for you to think about in that question.

When you choose your plausible range, remember that the goal is not to be 'right' by choosing a giant, guaranteed-safe range or, at the other extreme, to pretend to have extra confidence by choosing an overly narrow range. Rather, the goal is to choose your range such that you would be somewhat surprised if the true value falls outside your range. Numerically, choose the range so that it has a 2/3 probability of containing the true value.

That criterion explains why the range narrows after you estimate using divide and conquer. At first, you have little idea about the true value, so you would not be surprised were it to fall outside a fairly large range; after the estimate, you know more, your confidence in the estimate increases, and your plausible range shrinks.

In the following questions, you are often given a set of choices. In the box next to each choice, put your probability that the choice is correct. For example, if there are four choices, and you are completely undecided, give 0.25 to each choice. If you can eliminate two choices, but are completely undecided between the remaining two, give 0.5 to each of them. The online system for turning in the homework will offer you a form to enter your probabilities.

1 One spring, two masses

Two masses M and m are connected by a spring with spring constant k. What is the natural (angular) frequency of oscillation ω?

☐ $\sqrt{\frac{k}{m}}$

☐ $\sqrt{\frac{k}{M}}$

☐ $\sqrt{\frac{k(m+M)}{mM}}$

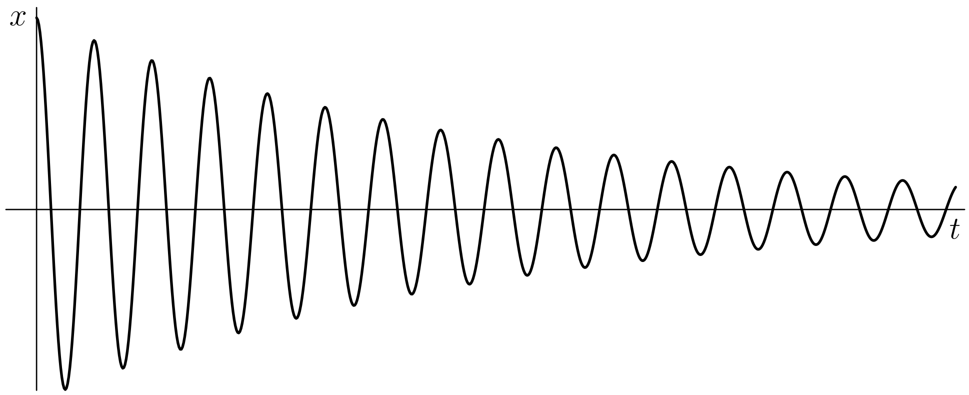
☐ $\sqrt{\frac{2k}{m+M}}$

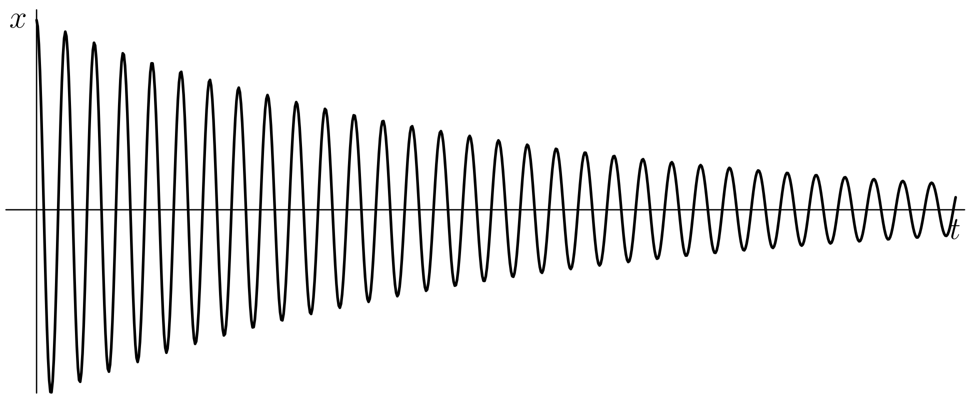
☐ $\sqrt{\frac{4k}{m+M}}$

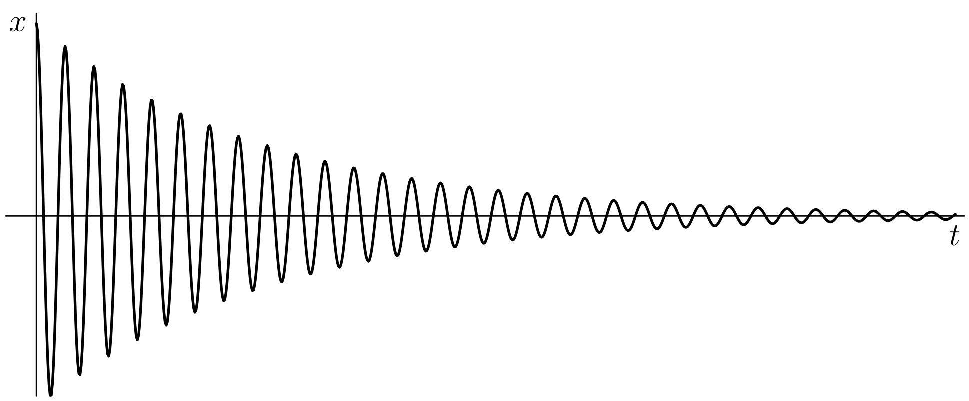
It is instructive to find the correct choice by guessing and by writing the differential equation(s)!

2 Find the largest-Q system

Each graph shows the response of a damped spring–mass system. Which system has the largest Q? (All the time axes have the same scale.)

☐ 

☐ 

☐ 

☐ impossible to determine without knowing the actual scale of the time axes

☐ impossible to determine without knowing whether the vertical (x) axes have the same scale

3 Spring in hydrogen

In modeling hydrogen as an electron connected to a proton by a spring, what fractional error in the oscillation frequency do you make by pretending that the proton is a wall (has infinite mass)?

$10^{\square} \pm \square$ ***or*** $10^{\square} \ldots \square$

4 Q of a swing

Go to a nearby playground swing and estimate its Q.

$10^{\boxed{}} \pm \boxed{}$ ***or*** $10^{\boxed{}} \ldots \boxed{}$

5 Combining multiple sources of damping

Imagine a spring–mass system (or a pendulum) with three sources of damping—for example, due to air resistance, to internal losses in the metal of the spring, and to friction against the table producing waves that carry away energy. The first source, alone, produces a Q of 10. The second, alone, produces a Q of 20. The third, alone, also produces a Q of 20. What is the Q of the system, with all three sources of damping?

$\boxed{} \pm \boxed{}$ ***or*** $\boxed{} \ldots \boxed{}$