Classical Mechanics I (Spring 2026): Homework #1

Due Mar. 23, 2026 (Mon, 23:00pm)

[0.5 pt each, total 6 pts / turn in as a single pdf file to eTL]

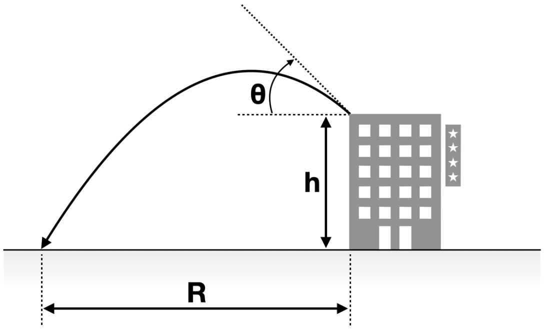
- By turning in your homework, you acknowledge that you have not received any unpermitted aid, nor have compromised your academic integrity during its preparation. (Remember the SNU College of Natural Sciences Honor Code, and the SNU AI Guideline!)
- Exhibit all intermediate steps to receive full credits. Only handwritten answers are accepted except for numerical problems or verifications — for which you print out and turn in not just the end results (e.g., plots) but also the source codes in your favorite tools such as MATLAB or MATHEMATICA.
- Gravitational acceleration $g = 9.8\,\mathrm{m\,s^{-2}}$. Assume negligible friction and air resistance, unless stated otherwise. Assume also that any cord connecting one object to another is massless, unless stated otherwise.
- For some problems you may want to use formulae in Appendices D and E of Marion, and/or more extensive references such as Zwillinger. Do *not* use the Lagrangian method until we cover it in the class.

1.-8. Thornton & Marion, Problems 2-5, 2-15, 2-25, 2-44, 2-52, 3-2, 3-21, 3-26

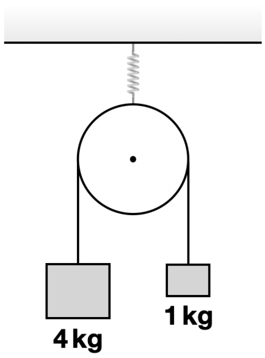
(Note: For Problems 2-5, assume that the pilot intends to keep his Mach 3 speed during the circular maneuver. For Problem 2-15, you may need to utilize an integral table; see the fourth bullet point above. For Problem 2-44, derive step by step the equation of motion depicting the small oscillation; this problem was briefly discussed in the class. For Problem 2-52(b), you should feel free to use any numerical tool of your choice, such as MATLAB, MATHEMATICA, or simply WOLFRAMALPHA. For Problem 3-2, the decrement of the motion is defined in Eq.(3.42). For Problem 3-21 and all other numerical problems, you are asked to submit your source code — or a proof of your work — as well; see the second bullet point above.)

9. A person fires a cannon from the top of a building of height h above a horizontal plain. Show that, for a given muzzle velocity v_i, the maximum horizontal range is achieved when the cannon

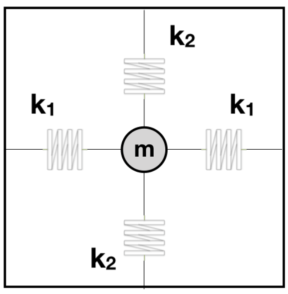
is fired at an angle θ satisfying $\csc^2\theta = 2\left(1 + \frac{gh}{v_i^2}\right)$. (Note: You may want to review the *implicit* differentiation, which appears in elementary calculus textbooks such as Stewart or 김홍종, or in mathematical physics textbooks like Boas (Chapter 4.6).)



10. Consider a pulley of mass 2 kg suspended from the ceiling by a spring balance. Two masses of 4 kg and 1 kg are attached to the opposite ends of a light string passing over the pulley, which is frictionless. When the system is released, the masses begin to move under the influence of gravity. While the system is in motion, determine the reading shown by the spring balance. Explain qualitatively why this reading is not simply 7 kg.

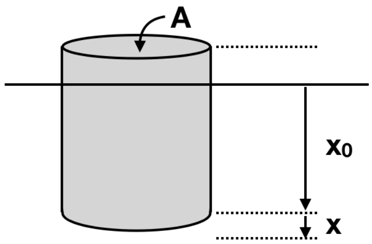


11. In the class we discussed two-dimensional simple harmonic oscillators. (a) Describe an example of the physical realization of Eqs. (3.19) and (3.27) using the figure shown below. (b) Reproduce Figures 3-2 to 3-4 in your textbook with your favorite numerical tool. For Figure 3-2, you don't have to remake all 10 panels; 2-3 panels should be enough.



[Problem 12 continues in the next page.]

12. An object of mass m, density $\rho_1 = 0.75\,\mathrm{g\,cm^{-3}}$, and uniform horizontal cross-sectional area $A = 1\,\mathrm{cm^2}$ is floating in a liquid of density $\rho_2 = 1.0\,\mathrm{g\,cm^{-3}}$. At equilibrium, the object displaces a volume $V_0 = 0.75\,\mathrm{cm^3}$ of the liquid.



(a) When the object is slightly pushed down from its equilibrium position, write down the equation governing small oscillations, while neglecting the retarding force of the liquid. Express the characteristic angular frequency in terms of the variables given, and evaluate its numerical value.

(b) Now consider the retarding force exerted by the liquid, whose magnitude for this object can be written as $2m\sqrt{g/c_\mathrm{r}}\,\dot{x}$, with $c_\mathrm{r} = 245\,\mathrm{cm}$. Write down the equation of small oscillations. Express its solution in terms of the variables given, and evaluate the numerical values of any coefficients that can be determined explicitly. State whether the motion is underdamped, overdamped, or critically damped.

(c) Determine the time required for the oscillation amplitude to fall below e^{-10} times its initial maximum value.