Physics UN2801 Professor Christ
due 11/03/2022

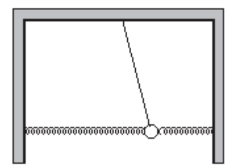
Assignment #7

Reading:

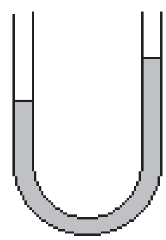
Nov 3 Kleppner and Kolenkow 13

Problems:

51. Kleppner and Kolenkow 11.5
52. Kleppner and Kolenkow 11.12
53. Kleppner and Kolenkow 11.13
54. A mass m at the end of a massless rod of length L swings as a pendulum with two horizontal springs for negligible mass and spring constants k_1 and k_2 acting on it. Both springs are relaxed when the rod is vertical. What is the period of small oscillations? [From Feynman Exercises in Physics]



55. A vertical U tube manometer of constant internal cross-section A contains a total length of liquid L. Find the period of oscillation of the liquid. Neglect friction and assume that the amplitude of oscillation is such that the two liquid surfaces remain within the straight vertical portions of the tube. [From Feynman Exercises in Physics]



56. Kleppner and Kolenkow 12.6
57. Using Python study the behavior of a pendulum made of a point mass $M = 1$ Kg suspended by a massless rod of length $l = 1$ meter and swinging in a vertical plane under the influence of gravity (use $g = 9.8$ m/sec^2) but *without* making a small angle approximation. You might begin with your solution problem 33 and change the force in that problem to the force here.
    (a) What is the numerical value for the oscillation period of this pendulum in the small angle approximation?
    (b) Start the pendulum at $t = 0$ with $\theta = 0$ and an initial velocity $v_0 = 3$ m/sec. Plot a graph of $\theta(t)$ for $0 \le t \le 10$, where θ is the angle between the pendulum rod and the vertical direction. Check that the period seen in the graph is consistent with the value you calculated in (a) above.
    (c) Add to this plot a second curve showing the known solution to this problem in the small angle approximation, for comparison.

    [Don't miss the final two parts of this question on the next page.]

(d) Next increase the initial velocity v_0 until the period of oscillation *increases* to approximately 8 seconds. What velocity is needed? (This can be done by trial and error. However, working out the value of v_0 which would cause the pendulum to swing all the way up to $\theta = \pi$ will make your guesses for v_0 better informed.) Plot a graph of the motion. (Recall that if you increase v_0 too much, the pendulum will swing "over-the-top".)

(e) Finally return to the initial velocity $v_0 = 3$ m/sec in part b) and include an additional frictional force proportional to the pendulum's velocity $\vec{F}_{\text{fric}} = -0.1\vec{v}(t)$ Nt sec/m. Again plot a graph of the resulting motion for a time interval of 30 seconds.

For this problem you need only include with your problem set solutions the three plots from parts (c), (d) and (e).