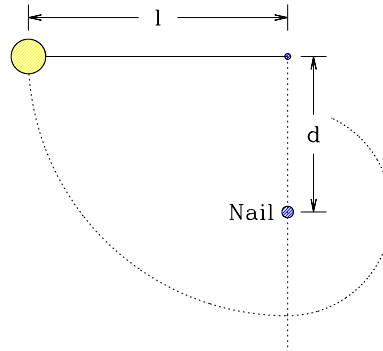


Astronomy 505: Homework #3 (Classical Mechanics)

1. An ideal ball-and-string pendulum (mass m and length l) is released from a horizontal position, to swing down the dotted arc shown in the figure. At the lowest point of the arc, the string will hit a nail positioned some distance d below the pivot.



- (a) How fast will the ball be going when it reaches the lowest point in its swing? (5 pts)
 - (b) Show that d must be at least $0.6l$ if the ball is to swing completely around in a circle centered on the nail. (5 pts)
2. A projectile of mass m is launched at an angle θ from vertical, from the surface of a planet of mass M and radius R , and with negligible atmosphere.
 - (a) Derive the minimum initial velocity v_{esc} required to ensure that the projectile never falls back to the surface. (6 pts)
 - (b) What is the ratio of v_{esc} for $\theta = 0$ (vertical launch), versus v_{esc} for $\theta = 45^\circ$? (4 pts)

For each remaining question, focus on the critical motivating physics. Give counter examples, sketch figures, and make your arguments as thorough and convincing as possible.

3. Consider a sine wave and a square wave, both with the same frequency. Which one contains more high frequency components? (3 pts)
4. A rabbit follows a little girl into a cave, far below the surface of the Earth.
 - (a) How will the gravity g_c in the cave compare to that at the surface? (2 pts)
 - (b) If the cave were at the center of the Earth, what would its gravity be then? (2 pts)
5. A drop of high surface tension liquid and a drop of low surface tension liquid are each placed on a clean piece of glass. One assumes a pancake shape, and the other a more spherical shape. Which is which? (4 pts)
6. The path left in the sky from a shooting star (meteor) can remain bright for several seconds, while the path left from a lightning bolt vanishes in far less than a second. What causes the difference? (8 pts)
Hint: The Earth's atmosphere is a big, big place ...
7. An air-filled balloon will float high on the surface when placed in water, while a weight will cause it to float lower, or even to sink. Suppose that you attach a weight that causes such a balloon to float so that its top just touches the surface of the water. If you now push the balloon below the surface of the water by hand, what will it do? (8 pts)