# Assignment No. 4

Physics 2P20

Due November 4, 2025, 9:30 in class

1. *Kleppner and Kolenkow, 2nd edition*, Problem 11.13.

2. *Kleppner and Kolenkow, 2nd edition*, Problem 4.3.

3. *Kleppner and Kolenkow, 2nd edition*, Example 4.21 and Problem 4.18.

4. For the frictionless roller-coaster on a vertical loop in the Example solved in the notes (*K&K* Pr.5.1), if the force pressing it against the track is never — even at the top of the loop — less than its weight, the starting elevation must be $z = 3R$ where $R$ is the radius of the loop. Assume this initial condition.

   (a) Obtain an expression for $\dot{\theta}$ valid for all points on the loop.

   (b) Separate the variables and integrate to calculate the total time $T$ it takes the roller-coaster to loop-the-loop.

   (c) Using Taylor series' expansion,

   $$(1-x)^{-n} = 1 + nx + \frac{n(n+1)}{2!}x^2 + \frac{n(n+1)(n+2)}{3!}x^3 + \ldots$$

   calculate $T$ to within a few percent, for $R = 25\,\mathrm{m}$.

5. *Kleppner and Kolenkow, 2nd edition*, Problem 5.6.

   *Hint:* The point where the block loses contact with the sphere corresponds to the point where the normal force on the block from the sphere goes to zero.