

# Assignment No. 4

Physics 2P20

Due November 6, 2023, 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,

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

calculate  $T$  to within a few percent, for  $R = 25$  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.