

## Homework Assignment 3 – Energy and Power

### Problem 1 (25 pts) – Work Done by a Force

A body of mass  $m$  was slowly hauled up the hill by a force  $F$  which at each point was directed along a tangent to the trajectory, as shown in Fig. 1, left. **Find the work** performed by this force, if the height of the hill is  $h$ , the length of its base is  $l$ , and the coefficient of friction is  $k$ .

### Problem 2 (25 pts) – Dead Loop

A cart of mass  $m$  moves along a dead loop, rolling down from the minimal required height to go through the highest point of the loop without losing contact with it (see Fig. 2, right). Assuming the system to be conservative, **find the force  $F_N$**  with which the cart presses on the loop at point A. The gravity constant equals  $g$ .

**Note:** Express your answer **in terms of given quantities only** (neither initial height nor radius of the loop are known).

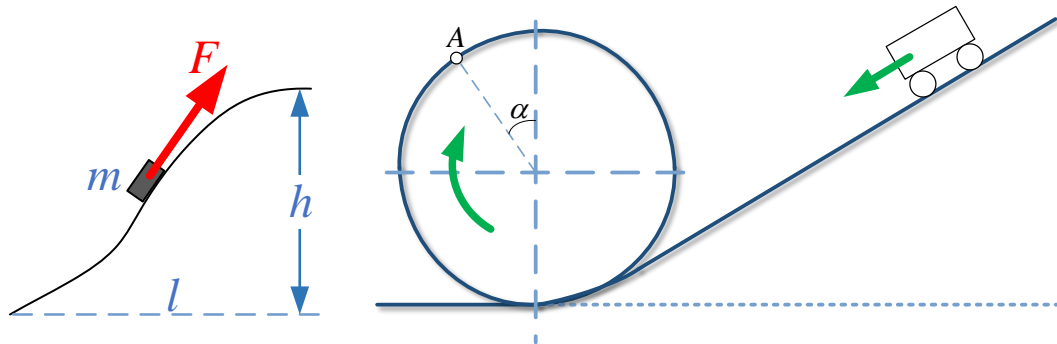
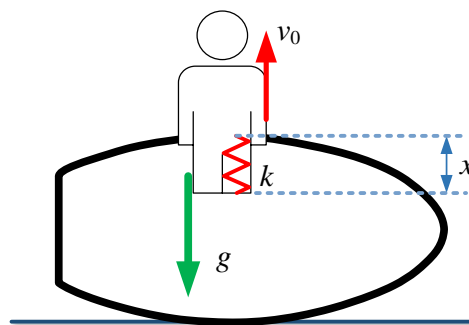


Figure 1. Schematics for Problem 1 (left) and Problem 2 (right)

### Problem 3 (25 pts) – Mafia 3 Glitch

One particular glitch in the Mafia 3 video game resulted in the player's character getting **launched into the air after being intermittently** stuck inside a motor boat. A hyper-realistic representation of this scene is shown in the figure below. The known quantities are: mass of the character  $m = 80$  kg, maximum launch height  $H = 70$  m, initial penetration of the character's feet into the boat's hull  $x = 0.5$  m, and the gravity constant is  $g = 9.81$  m/s<sup>2</sup>. Answer the following:

- Assuming that the boat's hull can be modeled as an ideal spring with the stiffness coefficient  $k$ , **what should be the value of  $k$**  (in N/m) so that the character is launched into the air by a given height  $H$ ? Neglect air drag **(15 pts)**
- What is the character's **initial speed  $v_0$**  (in km/h) at the start of the launch? **(10 pts)**



### Problem 4 (25 pts) – Power

The "Hypermammoth" tank's diesel engine has the maximum power of 90 MW at the speed of 60 km/h. **What forward force  $F$**  is exerted on the tank at this speed?