

Exercises in Introductory Physics I

Exercise Sheet 4
due to 13.11.23, 11:59 AM

Constant Friction

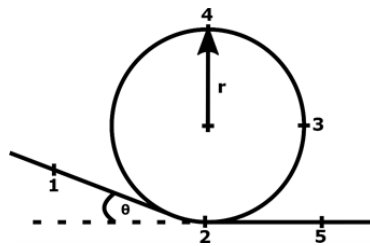
1. What mass m_{loc} does a locomotive need to have so it can pull a number of wagons with a total mass of $m_{\text{wag}} = 500 \text{ t}$ on a horizontal track and constantly accelerate them from $v_0 = 0$ to $v_1 = 80 \text{ km/h}$ within a distance of $d = 12 \text{ km}$. The friction coefficient between the wheels of the locomotive and the track is $\mu = 0.12$. (3P)

Dynamic Friction

1. A boat with mass $m = 1.5 \text{ t}$ is travelling at a speed of $v_0 = 100 \text{ km/h}$ when its engine is shut off. The magnitude of the frictional force \vec{f}_k between boat and water is proportional to the speed v of the boat $f_k(v) = v \cdot 70 \text{ kg/s}$.
 - a) Find the time required for the boat to slow down to $v_1 = 50 \text{ km/h}$. (2P)
 - b) Draw a $v(t)$ graph of the boats speed for a 20 s interval after the shut-down of the engine. (1P)

Circular Motion

1. For roller coasters in Germany the maximum tolerable acceleration is $6g$ (This is for the total acceleration acting on a person riding the roller coaster). A roller coaster runs through a loop (radius $r_{\text{loop}} = 30 \text{ m}$) with a constant speed v (see figure below).



Hint: The roller coaster does not accelerate between point 1 and 2

- a) Draw a $F(t)$ diagram for the force the track exerts on the wagons and the passengers rolling safely through the loop, from Point 1 to 5. (2P)
- b) Draw a $F(t)$ diagram for the total net force acting on the wagons and the passengers rolling safely through the loop, from Point 1 to 5 (2P)
- c) What is the maximum allowed speed for the roller coaster when entering the loop? (So that the maximum acceleration is not exceeded) (2P)

- d) What is the minimum allowed speed for the roller coaster when entering the loop? (So that the roller coaster does not fall off the tracks) (1P)

Elliptical Path

1. A car is moving with a constant speed along an elliptical path. The semi-major and semi-minor axes of the ellipse are A and B . The coefficient of friction between car and surface is μ .
 - a) Find the points where the acceleration is minimal and maximal. (1P)
 - b) Find the maximum speed so that the car does not start sliding from the path. (1P)