

## Applied Physics – Problem set #1

1. A ship is traveling at  $v_s = 20\text{km/h}$  toward east. On the deck a rat is running on the floor north-east with respect to the ship at  $v_r = 15\text{km/h}$ . What is the velocity of the rat compared to the Earth, and what angle does it make with the east direction?
2. A motorcyclist starts from rest and uniformly increases his speed along an  $r = 20\text{m}$  radius circle until  $t_1 = 4\text{s}$ . In the meantime, he covered  $s_1 = 9.6\text{m}$  distance. What is the magnitude of his acceleration at the  $t_1$  time?
3. A  $5\text{kg}$  object is placed on the ground, and it is pulled at an  $\alpha$  angle with respect to the horizontal, with a force of  $F = 25\text{N}$ . At what  $\alpha$  will the acceleration of the object be maximal, if the coefficient of friction between the object and the floor is  $\mu = 0.2$ ? ( $g = 10\text{ m/s}^2$  can be used)
4. Determine the necessary speed for which a  $700\text{ kg}$  Formula-1 car can travel at a constant speed upside down on the ceiling. The lifting force by the spoilers can be given as  $F_l = lv^2$  and the drag as  $F_d = bv^2$ , where the two coefficients are  $l = 3\text{ kg/m}$  and  $b = 1.1\text{ kg/m}$ . The coefficient of static friction between the rear tire (driven) and the road is  $1.8$ , and the rolling friction can be ignored for the front tire (just rolls).
5. A bump on the road can be approximated by a convex circular arc of  $40\text{m}$  radius looking at it from above. There is a  $1600\text{kg}$  car traveling at  $54\text{ km/h}$  speed approaching the bump.
  - a) What force does the car exert on the road when it's at the top of the bump?
  - b) At what speed would this force be zero („jumping”)?
  - c) What would be the force if the road was concave instead with the same radius?

### Homework #1

1. A light plane is headed due south with a speed relative to still air of  $185\text{ km/h}$ . After  $1.25$  hours, the pilot notices that they have covered only  $135\text{ km}$  and their direction is not south but  $15^\circ$  east of south. What is the wind velocity?
2. Determine the necessary speed for which a  $700\text{ kg}$  Formula-1 car can travel at a constant speed up on a vertical wall. The lifting force by the spoilers can be given as  $F_l = lv^2$  and the drag as  $F_d = bv^2$ , where the two coefficients are  $l = 3\text{ kg/m}$  and  $b = 1.1\text{ kg/m}$ . The coefficient of static friction between the rear tire (driven) and the road is  $1.8$ , and the rolling friction can be ignored for the front tire (just rolls).
3. What should be the rotational period of a space station with  $100\text{m}$  radius, so that the  $80\text{kg}$  astronaut feels normal due to the generated artificial gravity? What is the centrifugal force acting on him at this point?