

## Seminary exercise Nr. 5

### Systems of particles, collisions

1. A  $1.2\text{ kg}$  ball drops vertically onto the floor, hitting it with a speed of  $25\text{ m s}^{-1}$ . The ball bounces back with an initial speed of  $10\text{ m s}^{-1}$ . What impulse acts on the ball during the contact? If the ball is in contact with the floor for  $0.02\text{ s}$ , what is the magnitude of the average force on the floor from the ball?
2. Consider two mass points  $m_1$  and  $m_2$  at a mutual distance  $d$ . Determine the position of the mass centre. What is the result if the masses are the same?
3. Three particles of masses  $m_1=1.2\text{ kg}$ ,  $m_2=2.5\text{ kg}$  and  $m_3=3.4\text{ kg}$  form an equilateral triangle of edge length of  $140\text{ cm}$ . Where is the centre of mass of this system?
4. A  $3\text{ kg}$  object moving at  $8\text{ m s}^{-1}$  in the positive direction of an  $x$  axis has a one-dimensional elastic collision with an object of mass  $M$ , initially at rest. After the collision the object of mass  $M$  has a velocity of  $6\text{ m s}^{-1}$  in the positive direction of the axis. What is the mass  $M$ ?
5. A cart with mass  $340\text{ g}$  moving on a frictionless linear track at an initial speed of  $1.2\text{ m s}^{-1}$  undergoes an elastic collision with an initially stationary cart of unknown mass. After the collision, the first cart continues in its original direction at  $0.66\text{ m s}^{-1}$ . What is the mass of the second cart? What is its speed after the impact? What is the speed of the two-cart centre of mass?
6. A bullet of mass  $10\text{ g}$  strikes a ballistic pendulum of mass  $2\text{ kg}$ . The centre of mass of the pendulum rises a vertical distance of  $12\text{ cm}$ . Assuming that the bullet remains embedded in the pendulum, calculate the initial speed of the bullet.
7. A  $75\text{ kg}$  man rides on a  $39\text{ kg}$  cart moving at a velocity of  $2.3\text{ m s}^{-1}$ . He jumps off with zero horizontal velocity relative to the ground. What is the resulting change in the velocity of the cart?
8. A skater of mass  $70\text{ kg}$  stands on glassy ice. He puts himself in motion by firing horizontally a ball of mass  $3\text{ kg}$  at a speed of  $8\text{ m s}^{-1}$ . How far will the skater move after firing the ball? The coefficient of kinetic friction between the ice and the skates is  $0.02$ .
9. A wooden block with mass  $M=3\text{ kg}$  is lying on an horizontal table. It is hit by a bullet with mass  $m=5\text{ g}$  which moves horizontally. The bullet remains in the block after colliding with it. The block moves on the table to a distance  $d=25\text{ cm}$ . The coefficient of kinetic friction is  $\mu_k=0.2$ . Find the initial speed of the bullet.