Exam in Physics: *Classical Mechanics* (1h30)

Calculators and any type of documents are not allowed. Indicated grading is for your information only. Reply only to the questions asked. If you are short of space, you may use the back side of the exam.

Exercise 1: Multiple-choice questions (5 pts)

(Wrong answers are not penalized. Some questions may have more than one correct answers.)

1. The unit of work W is:
   a. Newton
   b. Joule
   c. The same as the unit of force
   d. The same as the unit of energy

2. If the work W of force is positive, it is said that the force is:
   a. resisting.
   b. recursive.
   c. driving.
   d. constant.

3. If a force is perpendicular to displacement, then its work:
   a. is zero.
   b. is maximum.
   c. is negative.
   d. depends on the norm of the force.

4. Kinematics is a branch of physics that studies:
   a. Motion independently of its cause
   b. The cause of motion
   c. cinema
   d. none of the above

5. In the polar coordinate system, the position vector is written as:
   a. $\overrightarrow{OM} = r\,\overrightarrow{u_r}$
   b. $\overrightarrow{OM} = \begin{pmatrix} r \\ 0 \end{pmatrix}$
   c. $\overrightarrow{OM} = \begin{pmatrix} 0 \\ r \end{pmatrix}$
   d. $\overrightarrow{OM} = \begin{pmatrix} r \\ \theta \end{pmatrix}$

Exercise 2: Javelin throw (8 pts)

A javelin of mass m = 0.8 kg is thrown from a point A at a height h = 1.95 m above the ground. Its initial velocity has magnitude v_0 =10 m/s and creates an angle $\alpha = 30°$ with the horizontal plane.

We ignore air resistance, and we assume that the gravitational acceleration is g=10m.s^{-2}.



1. Describe the study framework (reference frame, system under study, coordinate system). (1 pt)

2. Using Newton's second law, determine the acceleration vector. (1 pt)

3. Derive the expression for the velocity vector. Use the initial conditions to calculate the integration constant. (1 pt)

4. Derive the expression for the position vector. Use the initial conditions to determine the integration constant. (1 pt)

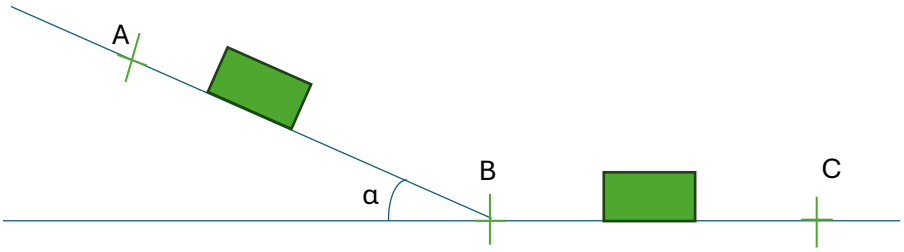
5. Establish the equation for the trajectory y(x). What type of trajectory is it? (1 pt)

6. How long does it take for the javelin to hit the ground? Calculate the numerical value. (2 pts)

7. At which distance from the origin is the point of contact? Calculate the numerical value. (1 pt)

Exercise 3: Motion on an included plane (7 pts)

A rectangular box of mass m = 0.1 kg released from point A of an inclined plane without initial velocity moves past point B up to point C (see figure below). We assume that friction is negligible along the AB segment of the trajectory, while along the BC segment, a force of friction $\vec{f}$ is exerted on the box.



Data given: $\alpha = 30°$, $g = 10\ m/s^2$, AB = 10 m

1. Draw on the figure all forces exerted on the box along the AB segment of the trajectory. (1 pt)

2. Determine the work of each force exerted on the box along AB, in terms of the mass m, the distance AB, the angle α and the gravitational acceleration g. (1 pt)

3. For which part of the trajectory can we use the theorem of mechanical energy conservation? Justify your answer. (1pt)

4. Determine the velocity of the box at point B using the theorem of mechanical energy conservation. Calculate the numerical value. (1 pt)

5. Draw on the figure all forces exerted on the box along the BC segment of the trajectory. (1 pt)

6. Determine the work of each force exerted on the box along BC in terms of the force of friction f and distance BC. (1pt)

7. Using the work-kinetic energy theorem calculate the distance BC over the which the rectangular box moves given that it stops at point C. Calculate the numerical value, given that the force of friction is constant with magnitude $f = 0.2\ N$. (1 pt)