1. Mechanics and fluids

An object of mass m_1 moves with velocity v_i along a horizontal plane without friction. At some point it collides with an object of mass m_2 which is at rest. There is a spring attached to this second object. The spring has elastic constant κ and negligible mass(fig. 1a). During the collision the spring reaches its maximum compression after which it remains blocked. Considering that the collision is inelastic, calculate:

1) final velocity of the two objects (**2 points**)
2) kinetic energy that is lost in the collision (**2 points**)
3) final amount of compression of the spring (**2 points**)

Let's now consider the situation in in fig. 1b. Consider that at t=0 the object of mass m2 starts its motion at distance Δx_0 from the rest position.
4)Calculate the expression for x(t) for object 2 (**2 points**)
5)Calculate the acceleration of object 2 after 3 seconds (**2 points**)

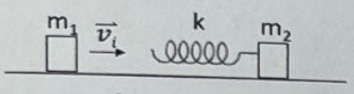

fig. 1a

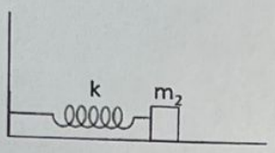

fig. 1b

2. Thermodynamics

An object made of iron, of mass m and at temperature T falls into a container. The container is filled with a mass m_w of water at temperature T_w. Considering that $C_{water}=10C_{iron}$, that $m=m_w/10$, and that $T=100T_w$,calculate:

1. by how much the water temperature increases (**2 points**)

Consider now n moles of an ideal gas that undergo the following cycle: A→B isothermal expansion at T_A, B→C isochoric transformation with volume V_B, C→D isothermal compression at T_C, D→A isochoric transformation with volume V_D. Consider that $V_B=2V_A$, $T_A=3T_C$, $C_v=3R/2$

2) Draw the PV diagram (**1 points**)
3) Heat exchanged in the cycle (**3 points**)
4) The efficiency of the machine (**2 points**)

3. Electromagnetism

In a region A of space there is a uniform magnetic field of intensity B along the $\hat{z}$ direction. We accelerate a proton from rest with a difference of potential ΔV so that it enters region A with velocity v in the $\hat{y}$ direction and perpendicular to the magnetic field.

1)Explain why the trajectory the proton describes in region A is circular
and how is the trajectory different in the case the incident particle is an electron (**2 points**)
2)Calculate the radius R of the trajectory and the angular velocity (**2 points**)

3) Imagine now that we apply an external electric field E such that the proton is not deviated by the magnetic field and continues to move along the y axis but such that the proton stops after horizontal distance x. Express E as a vector (module and direction). (**3 points**)

4)Consider now a coil of area A in the $\hat{x}\,\hat{y}$ plane and a magnetic field perpendicular to the coil along the $\hat{z}$ direction. The magnetic field increases linearly with time. How does the generated electromotive force vary with time and what's its direction? (**2 points**)

4. Modern physics

What is the photoelectric effect and why was it crucial to the development of quantum physics? (**3 points**)