1 Mechanics and fluids:

1a) Consider a road with friction coefficient μ. A car of mass m reaches a curve of radius R. What is the maximum safe velocity v with which the car stays in the curve? (**3 points)**

1b) After the curve, the car continues its linear motion and bumps into a wall with velocity v. The scattering lasts a time Δt and the car bounces back with velocity -v/2. What is the impulse and the average force that is exerted on the car? (**3 points)**

1c) Explain how you would measure the height of a building using a barometer **(2 points)**

1d) Consider a solid sphere. When floating in water a certain volume V is submerged. When floating in oil, a volume V/2 is submerged. Calculate the mass of the sphere. **(2 points)**
Input: ρ_{water}, ρ_{oil}

2 Thermodynamics

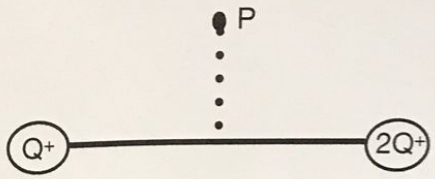
2) Consider 10 moles of an ideal gas that perform the following cycle of transformations: A->B (isothermal), B->C (isochoric), C->D (isobaric) and D->A (adiabatic).

2a) Draw the cycle in the PV plane **(1 point)**

2b) Calculate the change of internal energy in all the 4 transformations **(4 points)**
Inputs: Cv, R, P_A, V_A, T_C, V_B

2c) Calculate the variation of entropy associated to the spontaneous transformation of water into a mass m of ice at T_1 when the surrounding ambient, with which the water is in thermal contact, is at a warmer temperature T_2. Is this possible and why? **(3 points)**
Input: water latent heat L_f

3 Electromagnetism



3a) Consider two positive charges Q and 2Q as in the figure. Calculate the electric potential at point P **(3 points)**

3b) Consider a different scenario where there is an electric field along the $\hat{x}$ axis with non-constant intensity $E=E_0x$. What is the potential difference between two points A and B along the $\hat{x}$ axis separated by a distance L? **(3 points)**

3c) Consider a negative charge that moves from A to B. What is the change on its potential energy? What must be the charge velocity in A so that it stops and bounces back precisely in B? **(3 points)**

4 Modern physics: Describe the Compton effect **(3 points)**