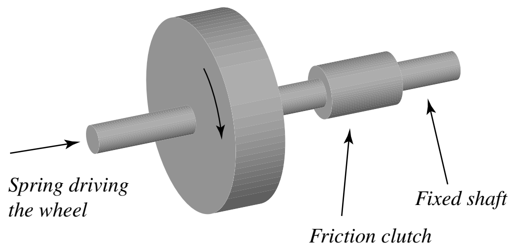
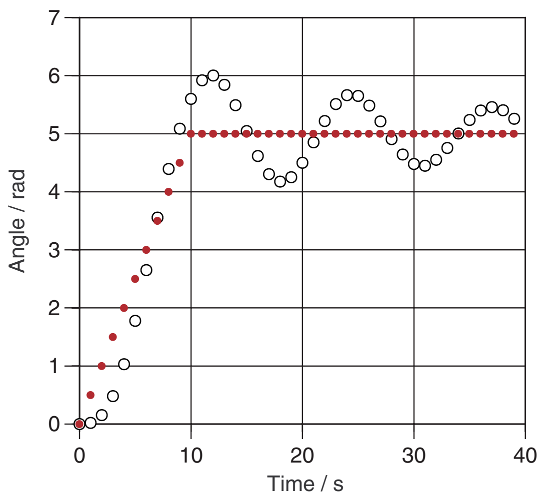
Physics Exam

1. A flywheel is positioned horizontally.On one side, it's shaft is connected to a torsion spring with a spring constant of 20 Nm. The other side of the shaft is attached to a viscous clutch with a damping factor of 5.0 Nms.

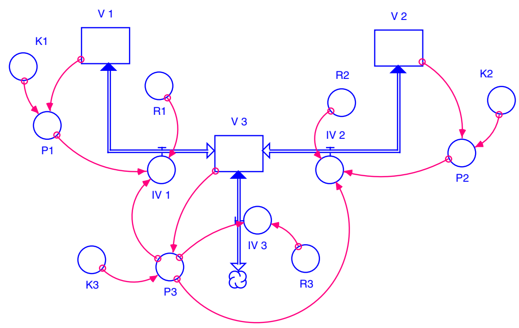


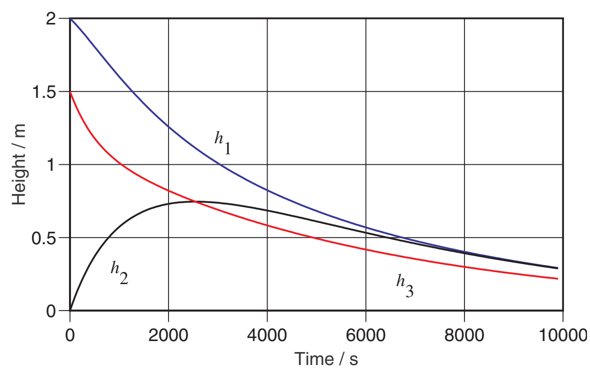
At the beginning, everything is at rest and the spring is relaxed. Then one end of the spring is turned at a constant rate for 10 s until it reaches an angle of 5.0 rad. It is then kept there (see diagram). The fly wheel then moves as depicted in the diagram.



a. Using the diagram, determine the greatest positive and the greatest negative values of the angular velocity.
b. What is the current of angular momentum (torque) because of the spring at approximately t = 15 s (When the angle of the wheel is the same as the angle of the spring, this means 5.0 rad?) What is the current of angular momentum (torque) because of the clutch at the same point in time?
c. What is the rate of change of the angular momentum of the wheel at that moment?
d. Why does the wheel oscillate?
e. Determine the angular frequency of the oscillations by using the diagram.
f. What is the wheel's moment of inertia?

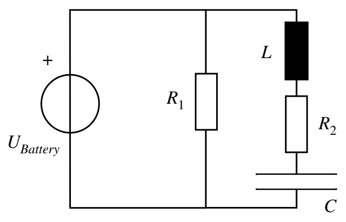
2. Three straight walled oil containers are connected as shown in the system dynamics diagram. The oil has a density of 1000 kg/m^3. Assume a value of 10 N/kg for the strength of the gravitational field. The three capacitances are $1{\cdot}10^{-4}$ m^3/Pa, $0.5{\cdot}10^{-4}$ m^3/Pa and $1.0{\cdot}10^{-4}$ m^3/Pa, respectively. The three resistances are $1.5{\cdot}10^7$ Pa·s/m^3, $3.0{\cdot}10^7$ Pa·s/m^3 and $2.0{\cdot}10^7$ Pa·s/m^3, respectively. The flow satisfies the law of Hagen and Poiseuille. Induction is ignored.



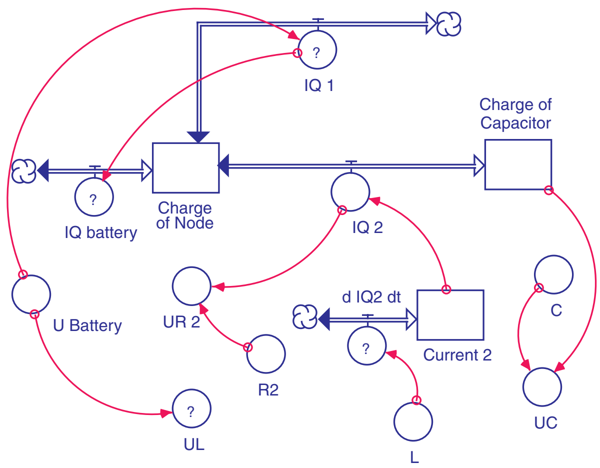


a. How much energy is stored in the system at the beginning because of the storage of oil?
b. What is the flow of volume out of the first tank at the moment t = 2000 s?
c. What is the energy current out of this tank at this moment?
d. What is the hydraulic power in the pipe between the first tank and the third tank at this moment?
e. What is the rate of change of the energy stored in the first tank? Why?
f. Which processes lead to the change of the energy stored in the entire system?

3. The circuit below (R_1 = 2 Ω, R_2 = 2 Ω, C = 100 µF, L = 1 mH, $U_{Battery}$ = 10 V), is to be modeled. At the beginning, the capacitor is uncharged, and there is no current of charge. At the moment t = 0, the battery is connected.



The relevant system dynamics diagram is shown below.



a. Complete the system dynamics diagram.
b. What is the equation for UL?
c. What is the equation for IQ_battery?
d. Determine the voltages across the three elements in branch 2 just after connecting the battery. Explain.
e. Determine the voltages across the three elements in branch 2 after a long period of time. Explain.

4. Two straight walled tanks are connected to each other by a hose connected to their bottoms. A second hose leads from the bottom of the second tank to the environment (also at the level of the bottoms of the tanks).

   The tanks are filled with oil whose properties are known. The cross sections of the tanks and the lengths and radii of the hoses are given.
   At a certain moment the volume current through the second hose and the fluid level in the first tank are known.
   You are asked to determine the rates of change of the volumes of the tanks for this moment.
   Solve the problem using exactly these steps:
   1. Sketch of situation
   2. Choose system(s)
   3. Free-body diagrams including all currents
   4. Formulate laws of balance
   5. Potentials and potential differences
   6. Formulate special laws
   7. Create formal solution (result in function of the known quantities).