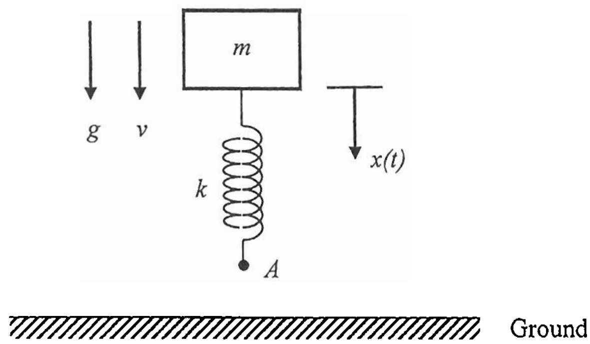
國立台灣科技大學九十九學年度碩士班招生試題

系所組別： 自動化及控制研究所碩士班乙組

科　　目： 控制系統

(總分為100分)

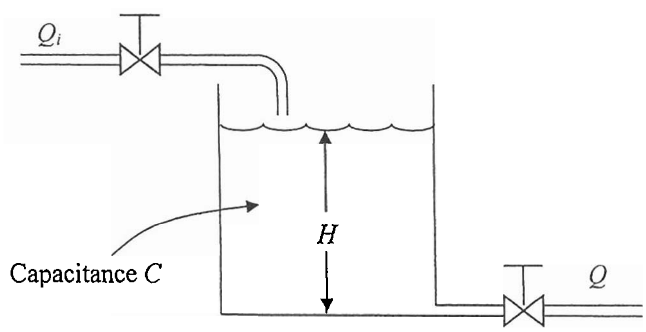
1. To study the landing impact phenomenon of a light aircraft, the airplane is modeled as shown where m denotes the lumped mass of the airplane and k represents the stiffness of the landing gear. The airplane has a vertical descent velocity of v when the landing gear (point A) touches the ground. Let $t = 0$ at the time of contact and let $x(0) = 0$. Find
   (1) the vertical position of the mass as a function of time during the time that the spring remains in contact with the ground. (10%)
   (2) the time at which the spring loses contact with the ground upon rebound. (5%)



2. In the liquid-level system as shown below assume that the outflow rate Q (m^3/s) through the outflow valve is related to the head H (m) by

$$Q = K\sqrt{H} = 0.01\sqrt{H}$$

Assume also that when the inflow rate Q_i is 0.015 m^3/s, the head stays constant. At $t = 0$ the inflow valve is closed and so there is no inflow for $t \geq 0$. Find the time necessary to empty the tank to half the original head. The capacitance of the tank is 2 m^2. (10%)



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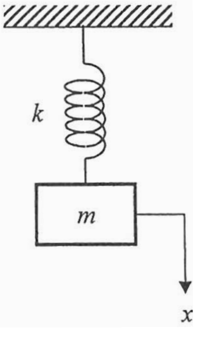
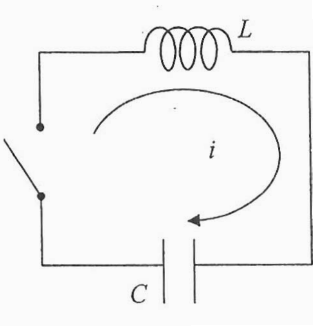
3. Show that the mechanical and electrical systems given below are analogous. Assume that the displacement x in the mechanical system is measured from the equilibrium position and that mass m is released from the initial displacement $x(0) = x_0$ with zero initial velocity, or $\dot{x}(0) = 0$. Assume also that in the electrical system the capacitor has the initial charge $q(0) = q_0$ and that the switch is closed at $t = 0$. Note that $\dot{q}(0) = i(0) = 0$. Obtain x(t) and q(t). (10%)

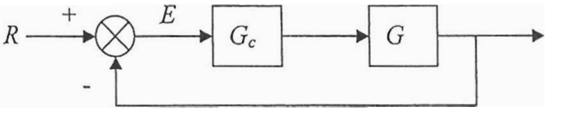




4. (1) In the Figure shown below with $G(s) = \dfrac{1}{[(s+1)(0.5s+1)]}$, sketch root loci for PI control $G_c = K_p + K_i/s$ if (i) K_i/K_p large, (ii) $K_i/K_p = 2$, (iii) $K_i/K_p = 1$, and (iv) $K_i/K_p = 0.1$. (5%)

(2) Which of conditions (i) to (iii) is preferred, and why? (5%)

(3) For condition (iv), will the locus branches at considerable distance to the origin differ much from those for P control $G_c = K_p$? If not, why not? (5%)



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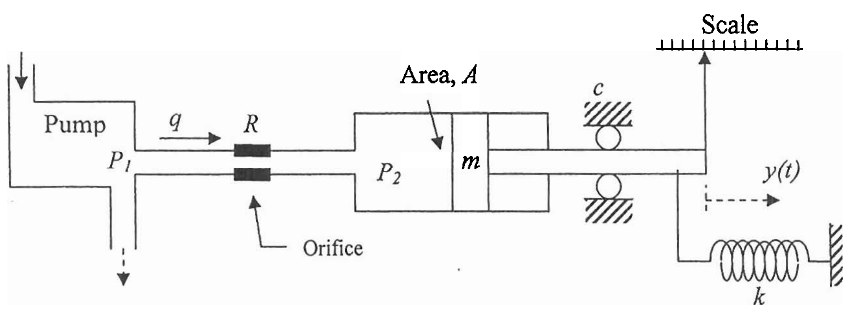
5. An instrument for measuring the transient pressure $P_l(t)$ at the discharge of a pump is shown below. Neglect the compressibility of the liquid, obtain the transfer function relating the output displacement $y(t)$ to the input P_l. The scale indicator is modeled as a mass-spring-damper system with spring constant k and viscous friction coefficient c. (15%)



6. A plant with transfer function $G(s)=\dfrac{9}{s^2+9}$ is to be controlled to achieve no more than 16.3% overshoot and a 2% settling time of less than 2 sec, under a unit step command input. Sketch the root locus and design a proper controller to satisfy these specifications. (15%)

7. An engineer would like to use the tachometer to measure the speed of a motor shaft, and achieve position control goal. He models his problem as the block diagram below, with $G(s)=\dfrac{\omega}{V_a}(s)=\dfrac{K_1}{\tau_1 s+1}$, where K_1, τ_1 are the model parameters. He plans to use a proportional controller (K_P) to track the position command. Answer the following questions:

(1) What is the closed-loop system transfer function, $T(s)\triangleq\dfrac{\theta}{\theta_d}(s)$? (10%)

(2) What is the system type? Do you expect that the output will track the step command with zero steady state error? What will the answer be if there is measurement noise in the tachometer? Give specific reasons to support your claims. (10%)