	Alexandria Higher Institute of Engineering & Technology (AIET)			
	Department of: Mechatronics		Fourth Year	4th Year
	EME403	Dynamic System Analysis		Final, Jan., 21, 2015
	Examiners:	Dr. Rola Afify and committee		Time: 3 hour

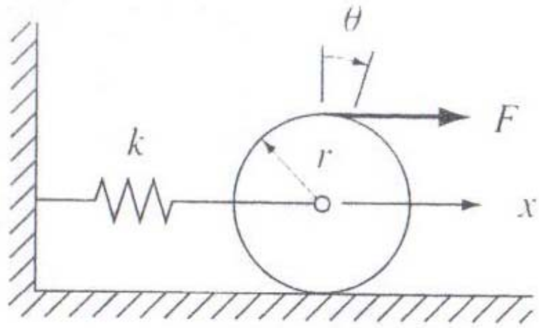
Answer the following questions:

Question one (15 marks)

A) For mechanical systems, define: Spring, damper, and discrete mass.

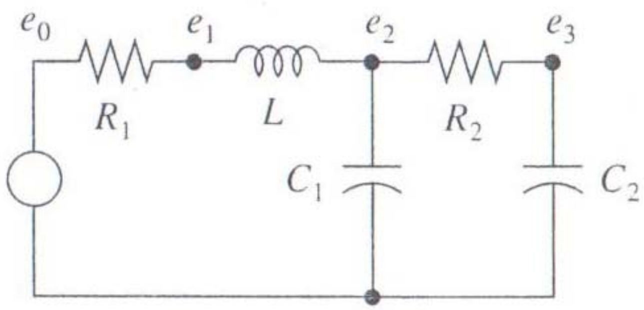
B) Prove that the solution of the first order differential equation using ramp input $u(t) = u_o$ will be in this form $x(t) = x_o e^{-t/\tau} + G u_o \left[t - \tau(1 - e^{-t/\tau}) \right]$.

C) A portion of a mechanical device may be idealized as a uniform, homogeneous wheel rolling without slipping on a horizontal surface, as shown in figure. The center of the wheel is fastened to the frame of the device by a linear spring, and a force is applied at the top of the wheel. Find the equation of motion that governs the horizontal position of the center of the wheel.

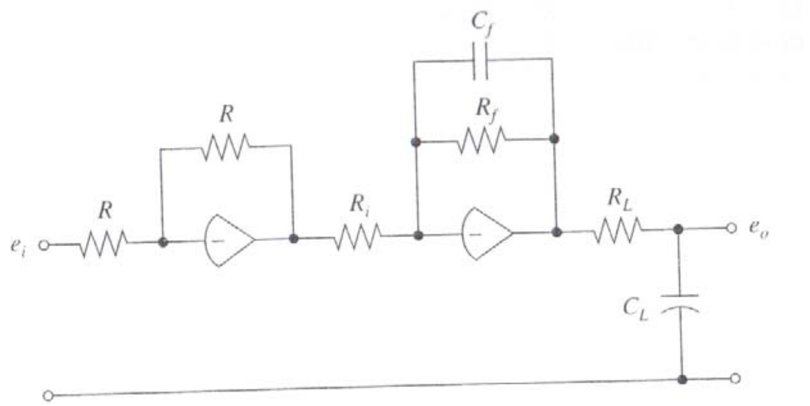


Question Two (15 marks)

A) Write the modelling equation for the circuit shown in figure. What is the gain?



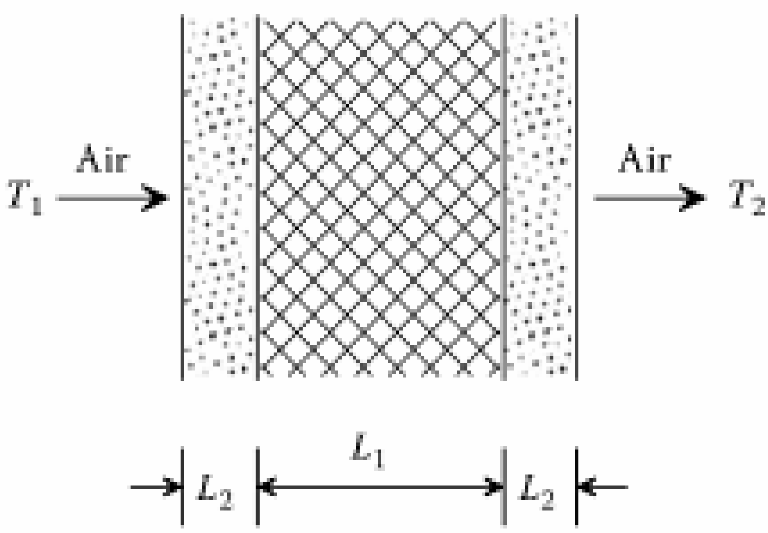
B) An electronic circuit with an op-amp buffer is shown in figure. Derive the differential equation for e_o as a function of the input e_i. Calculate the static gain, natural frequency, and damping ration if R_f = 10 kΩ, R_i = 10 kΩ, C_f = 1 µf, R_L = 500 Ω, and C_L = 10 µf.



Question Three (15 marks)

A) Declare, with neat sketches, basic effects of thermal systems.

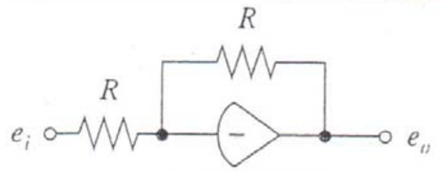
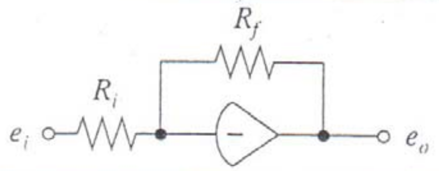
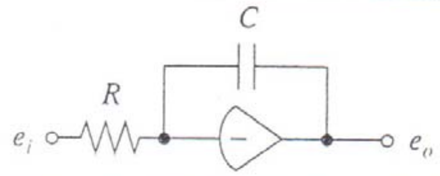
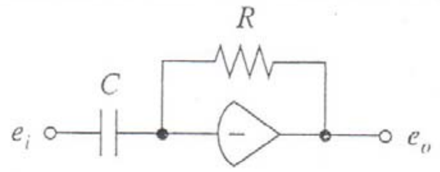
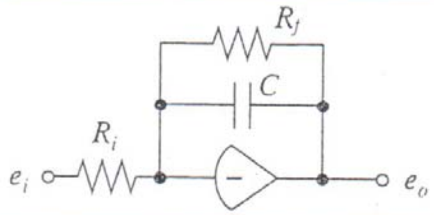
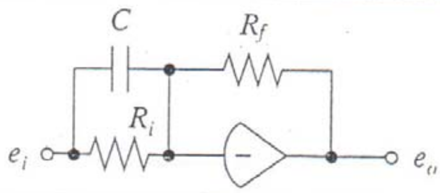
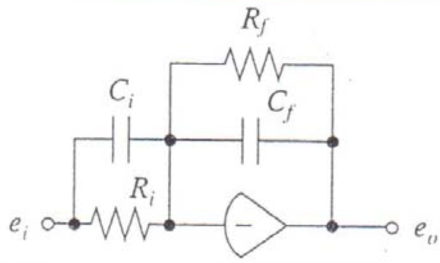
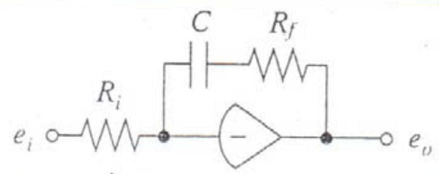
B) Consider heat transfer through an insulated wall as shown in figure. The wall is made of a layer of brick with thermal conductivity k_1 = 0.5 W/(m.°C) and two layers of foam with thermal conductivity k_2 = 0.17 W/(m.°C) for insulation. The left surface of the wall is at temperature T_1 = 38°C and exposed to air with coefficient h_1 = 10 W/(m^2.°C). The right surface of the wall is at temperature T_2 = 20°C and exposed to air with coeffiecient h_2 = 10 W/(m^2.°C). The thickness of the brick layer is 0.1 m, the thickness of each foam layer is 0.03 m, and the cross-sectional area of the wall is 16 m^2. Write the modelling equation and determine the heat flow rate through the wall.



Question Four (15 marks)

A) Compare between viscosity of liquids and gases.
B) For Fluid systems, define: capacitance, inductance, and resistance.

TABLE 4.1 Op-Amp Circuits.

Description	Transfer Function	Circuit
Sign Changer	$e_o = -e_i$	
Amplifier	$e_o = -\frac{R_f}{R_i} e_i$	
Integrator	$e_o = \frac{-e_i}{\tau D}$ $\tau = RC$	
Differentiator	$e_o = -\tau D e_i$ $\tau = RC$	
Lag	$e_o = \frac{-\frac{R_f}{R_i} e_i}{(\tau D + 1)}$ $\tau = R_f C$	
Lead	$e_o = -\frac{R_f}{R_i}(\tau D + 1)\ e_i$ $\tau = R_i C$	
Lead-Lag or Lag-Lead	$e_o = -\frac{R_f}{R_i} \frac{(\tau_i D + 1) e_i}{(\tau_f D + 1)}$ $\tau_i = R_i C_i$ $\tau_f = R_f C_f$	
Bandwidth-Limited Integrator	$e_o = \frac{-(\tau_f D + 1)\ e_i}{\tau_i D}$ $\tau_f = R_f C$ $\tau_i = R_i C$	
Bandwidth-Limited Differentiator	$e_o = \frac{-\tau_f D e_i}{(\tau_i D + 1)}$ $\tau_f = R_f C$ $\tau_i = R_i C$