College of Engineering, Pune.
Electrical Engineering Department
Class: M.Tech and B.Tech -Electrical,
Subject: Energy Conservation and Auditing (EE-5117),
End-Semester Examination-November- 2011

Maximum Marks: 50, Time: 3 hours;
Instructions: Question 1 is COMPULSORY. Solve any THREE questions from Q2 to Q5.
All questions carry 10 marks each. Assume suitable data, if necessary.

Q.1. Answer the following by choosing the correct alternative and Rewrite the correct sentences:

01) The minimum capacity of any closed vessel which generates steam under Indian Boilers Regulation Act is ___.

a) 2.275 liters b) 22.75 kilo liters c) 227.5 liters d) 22.75 liters.

02) For higher boiler efficiencies, the feed water is heated by ____.

a. recuperator b. convective heater c.superheater d.economiser

03) Name the predominant loss component for furnace oil fed boiler.

a) losses due to radiation and convention b) loss due to hydrogen in fuel

c) loss due to dry flue gas d) loss due to moisture in fuel

04) What type of steam is generally used for power generation/application?

a) high pressure steam with super heat b) dry saturated low pressure steam

c) dry saturated steam with high pressure d) wet steam with very high pressure

05) In industrial applications the type of trap used for main stream lines are:

a) thermodynamic b) thermostatic c) bimetallic d) float

06) Velocity of steam in steam pipe is directly proportional to

a) number of bends in pipe b) specific volume of steam

c) length of pipe d) none of the above

07) Which type of insulation is more economic or energy efficient for steam pipelines carrying saturated steam?

a) glass wool b) ceramic fibre c) calcium silicate d) fibre bricks

08) In a combined cycle power plant consisting of gas turbine and waste heat boiler, the exhaust gas temperature is ____.

a) around 150 °C b) around 500 °C

c) around 300 °C d) around 400 °C

09) In a glass industry, exhaust gas from the glass melting furnace is used for power generation by installing steam boiler and turbine. Then the type of co-generation is called as: a) gas turbine b) diesel generator c) topping cycle d) bottom cycle

10) The rating required for a DG set with 500kW connected load and with diversity factor of 1.5, 80% loading and 0.8 power factor is -------.

a) 520 kVA b) 600 kVA c) 625 kVA d) 500 kVA

Q2.a) Explain the method of calculation of efficiency of a boiler by indirect method.

Q2.b) Calculate the fuel oil savings by providing an Economiser for a boiler. The performance data of the boiler are given as below:

- Average quantity of steam generated : 5 T/h
- Average flue gas temperature : 315 °C (without economiser)
- Average steam generation / kg of fuel oil : 14 kg
- Feed water inlet temperature : 110°C
- Fuel oil supply rate : 314 kg/h
- Flue gas quantity : 17.4 kg/kg of fuel
- Gross calorific value of fuel : 10,000 kCal/kg
- Rise in feed water temperature by providing economizer: 26 °C
- Annual operating hours : 8600

Q3.a) List and explain the different type of heat losses in furnaces.

Q3.b) In an industry one 30 kWh operating load, electrical furnace to be converted into furnace oil fired. Estimate the furnace oil (litre) requirement, considering the following:

Calorific value of FO : 9200 Kcal/kg

Density of FO (kg/litre at 15 °C) : 0.9

Efficiency of electrical furnace : 70%

Efficiency of FO fired furnace : 55%

Q4.a) What are the merits of VSD application in case of pumps?

Q4.b) List the energy saving opportunities for a fan application.

Q5.a) What is cogeneration? Explain Briefly. Differentiate "Back Pressure Turbine" and "Extraction Condensing Turbine" through sketches.

Q5.b) Evaluate the option of boiler replacement for the following boiler with a new boiler of 84% efficiency. The cost of new boiler is Rs 30.00 lakh

Data of present boiler:

- Average steam generation from the boiler: 5000 kg/h
- Fuel used: furnace oil
- Enthalpy gained by the steam in boiler: 600 kcal/kg of steam
- Cost of furnace oil: Rs 15000 per ton (Rs. 15 per kg)
- Gross calorific value of the fuel: 10000 kcal/kg
- Annual operating hours of the boiler: 6000 h
- Boiler efficiency: 80%

Boiler replacement option can be evaluated by considering the following

- Evaporation rate, kg of steam per kg of fuel
- Cost of steam, Rs. Per kg
- Annual Cost of steam

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End Semester Exam. Nov 2011

F.Y. M. Tech (Control System)

Digital Control systems (EE 5212)

Time Duration 3Hrs. Max. Marks (50)

Instructions: Solve all questions. Assume suitable data if needed.

(Q.1a): Country A has population 100 million and a city B in the country has population 10 million in 1970. Suppose that every year 4% of the previous year population of the city B moves out of the city B and 2% of the previous year population of the country outside city B moves to city B. Assume natural increase in the population is 1%. Formulate discrete control problem. Find the population of the country in the year 1980.

(Q.1b): A discrete time system is described by

$$\begin{aligned} y(k+2) + y(k+1) + 6y(k) &= u(k) \\ y(0) = y(1) &= 0. \end{aligned}$$

Find y(k)

(Q.2a): Discuss the effect of choice of sampling time on controllability and stability.

(Q.2b): Discretize the following system for $\tau = 0.5Sec.$ Find state transition matrix further.

$$\dot{\mathbf{x}} = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -1 \end{pmatrix} \mathbf{x} + \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} u.$$

Q.(3a): What is observability and re-constructibility? Illustrate why " Observability implies re-constructibility but not vice a versa."

Q.(3b): Check if the following system is reachable. In how many time steps it is controllable?

$$\mathbf{x}(k+1) = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0.20 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.5 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix} \mathbf{x}(k) + \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \\ 1 \end{pmatrix} u(k).$$

Q.(4a): For the plant described below design a state observer such that the poles governing the observer error dynamics are required to lie at $-0.2 \pm j0.1$.

$$\mathbf{x}(k+1) = \begin{pmatrix} 0.5 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \mathbf{x}(k) + \begin{pmatrix} 1 & 4 \\ 0 & 0 \\ -3 & 2 \end{pmatrix} \mathbf{u}(k) \text{ and } y(k) = \begin{pmatrix} 1 & 0 & 1 \end{pmatrix} \mathbf{x}(k)$$

Q.(4b): Given the system

$$\begin{pmatrix} x_1(k+1) \\ x_2(k+1) \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ -0.5 & -1 \end{pmatrix} \begin{pmatrix} x_1(k) \\ x_2(k) \end{pmatrix}$$

Check the stability using Lyapunov approach.

Q.(5a): Examine the stability of the following system using Jury's method

$$z^4 - 1.2z^3 + 0.07z^2 + 0.3z - 0.08 = 0.$$

Q.(5b): Consider the discrete-time unity feedback control system whose open loop transfer function is given as below

$$G(z) = \frac{k(0.3679z + 0.2642)}{(z - 0.3679)(z - 1)}$$

Determine the range of k for stability. Use Jury stability test.

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End Semester Exam. Nov 2011

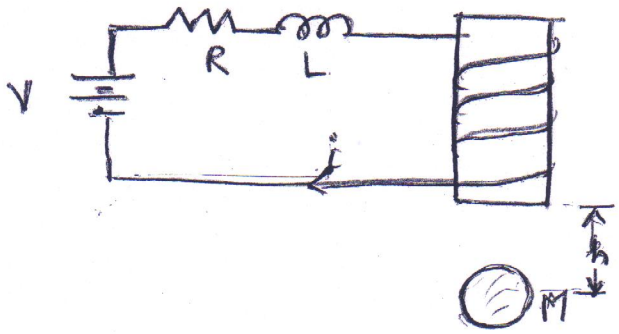
F.Y. M. Tech (Control System)

Modeling of dynamic systems (EE 5201)

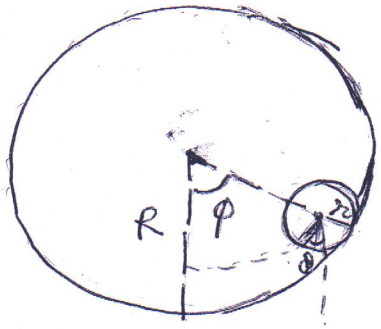
Time Duration 3Hrs. Max. Marks (50)

Instructions: Solve all questions. All questions carry equal marks. Assume suitable data if needed.

(Q.1): A magnetically suspended steel ball is shown in the schematic below. Obtain mathematical model of the system. Obtain linearized state space model using Jacobian linearization. Obtain zero input response.



Q.(2): A sphere of radius r is constrained to roll without slipping on the lower half of the inner surface of a hollow cylinder of inside radius R as shown in the figure below. Determine the equations of constraint, Lagrangian and dynamic equation of motion.



Q.(3): In a resource management problem, a single species os fish is considered. This fish

is a renewable resource in the sense that the stock of the fish is itself reproducing. If x is measure of fish, and the rate of increase of fish is $K(M-x)$ for positive K and M. Let u be the harvesting rate. Write the dynamical equation of the system. With constant harvesting rate, what should be maximum harvesting rate. What is disadvantage of this policy? Assuming constant harvesting rate with $H < 0.25KM^2$, develop linearized model for the change of resource level. Use the linearized model to characterize the fisheries resource.

Q.(4): Develop a method to obtain model of second order over damped system from impulse response data. Hence obtain a numerical model from the following impulse response data.

t (Sec)	5	8	10	12	16	20
Impulse response :g(t)	0.9079	0.2050	0.10197	0.00392	0.00056	0.000078

Q.(5): Develop a state space model of a field controlled dc motor. Comment on zero input response and zero state response.

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END SEMESTER EXAMINATION
Nonlinear Dynamical Systems

Programme: M.Tech. (Electrical)
Specialization: Control Systems
Year 2011-2012 **Date: 21/11/2011**
Duration: 3Hour **Max. Marks: 50**
Instructions:

1. Attempt any FIVE questions..
2. Assume data, wherever necessary.
3. Figures to right indicate full marks.

Q1a What are various types of nonlinearities present in the system? Explain them. **5**

b A linear system with transfer function : **5**

$G(s) = \dfrac{15}{s(s+2)(s+5)}$ is in cascade with a relay. The relay is described by:

Output=0 for deadzone of ± 0.2
=1 for $input \geq 0.2$
= -1 for $input \leq -0.2$

Investigate the stability of the system. Find frequency and amplitude of the limit cycle, if any.

Q.2a Explain Krasovskii's method to examine the stability of the equilibrium point x(0,0) of the system. **10**

Apply it to the system given: $\dot{x}_1 = -x_1 \qquad \dot{x}_2 = x_1 - x_2 - \dfrac{x_2^3}{3}$

Q.3a What are the conditions for input-state realizability of an n-th order nonlinear system? **5**

b Convert the following nonlinear system into normal form using diffeomorfism: **5**

$$\begin{bmatrix} \dot{X} \end{bmatrix} = \begin{bmatrix} -x_1 \\ x_1 x_2 \\ x_2 \end{bmatrix} \begin{bmatrix} e^{x_2} \\ 1 \\ 0 \end{bmatrix} \quad \text{and} \quad y = h(x) = x_3$$

Q.4a What are the zero dynamics with respect to I/O linearization of nonlinear systems? Find the zero dynamics of above system in **Q.3b**. Are they stable? **5**

b Define Lie bracket for two vector fields f and g defined over R^n. Compute the Lie bracket for the nonlinear system with: **5**

$$\begin{bmatrix} f \end{bmatrix} = \begin{bmatrix} -2x_1 + ax_2 + \sin x_1 \\ -x_2 \cos x_1 \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} g \end{bmatrix} = \begin{bmatrix} 0 \\ \cos(2x_1) \end{bmatrix}$$

PTO

Explain the term : Relative degree of a system:

Consider the Van der Pol's equation

$$\dot{x}_1 = x_2$$

$$\dot{x}_2 = -x_1 - (x_1^2 - 1)x_2 + u$$

Calculate the relative degree taking output y as:

i. $y = x_1$

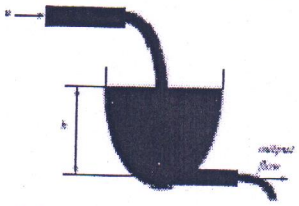
ii. $y = x_2$

iii. $y = x_1 + x_2^2$

Design the state feedback controller in the first (i) case.

10

Q.6 Consider a fluid level control system as shown below:



Find the dynamic model of the system and design a feedback linearization control law for controlling the level at the desired value.

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