



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2015

Module Number: EE5218

Module Name: Energy and Environment

[Three Hours]

[Answer all questions, each question carries 14 marks]

- Q1 a) i) Give the reasons why electrical energy is considered as superior over other energy forms.
ii) Explain briefly, the main structural behavior of energy sector in Sri Lanka.
iii) Explain briefly, the relationship between the energy and the economy.

[4 Marks]

- b) i) Explain briefly the self-price elasticity and the cross-price elasticity.
ii) What is meant by energy intensity?
ii) The energy-economy related data of Country A is given in Table Q1. The ratio of GDP in 2003 to GDP in 2013 is 0.56. Calculate the energy consumption of diesel and electricity for the year 2013, if the energy demand ratio of electricity to diesel is 0.65.
Consider 2003 as the base year.

Table Q1

Year	Country A
2003	Diesel (Thousand toe) = 28736 Electricity (Thousand toe) = 12736
2013	Energy Intensity Index = 0.945

[5 Marks]

- c) i) Sketch an arrangement of a hydroelectric power plant.
ii) Explain briefly, the types of hydro power stations.
iii) A hydro-electric power plant operates at a mean head of 40 m. The reservoir has a catchment area of 480 km². Determine the maximum power output of the plant, if the average annual rainfall in the area is 1100 mm. The loss of the head in the penstock is estimated to be 10%. Assume that the turbine efficiency is 85% and the generator efficiency is 92%.

[5 Marks]

- Q2 a) i) Name the types of steam power plants.
ii) Briefly explain the main factors in which the thermal efficiency of a steam power plant depends on.
iii) Explain briefly, the site selection of a steam power plant.

[3 Marks]

- b) i) Describe the principle of operation of an open cycle gas turbine plant.
 ii) Describe the principle of operation of a closed cycle gas turbine plant.
 iii) Describe the principle of operation of a combined cycle gas turbine plant.
 iv) Draw the schematic diagram of a gas turbine power plant in which the thermal efficiency is improved.
 v) Draw the temperature entropy diagram of the plant in part b) i) by clearly showing the variations of each section in the diagram. [5 Marks]
- c) i) Sketch a general layout of a diesel power plant.
 ii) Explain briefly, the starting system of a diesel power plant. [3 Marks]
- d) A typical $10 \times 4 \text{ m}^2$ commercial solar cell costs Rs. 150 per watt of electricity generating capacity. A photovoltaic cell has a conversion efficiency of 9%, a performance efficiency of 0.8 and a lifetime of 30 years. The average solar insolation is 1800 kWh/m^2 per year and daylight averages 12 hours per day. Determine the time that it takes the solar cell to pay its initial cost, if the electricity is displaced by the solar cells and costs Rs. 10/kWh in the retail market. [3 Marks]

- Q3 a) i) Explain briefly, how electricity can be utilized in the domestic sector.
 ii) State the types of lighting control systems and briefly explain them.
 iii) XYZ company has its security lights on timers. The company identifies that an average operating time of one hour per day can be saved by using photocell controls. The company has 100 mercury vapor lamps of 1,000 Watts each and the lamp ballast increases the electric load by 15%. The company pays Rs. 6/kWh. Assume that there is no demand savings. The unit cost of photocell control is Rs. 1500 and each lamp must have its own photocell. It will cost the company an average of Rs. 500 per lamp to install the photocells.
- I. Determine the operating cost of security lights without photocell controls during one year.
 - II. Determine the simple payback period for installing photocell controls to the security lighting system.
 - III Do you recommend a photocell control lighting system for the company?

[7 Marks]

- b) i) What is the purpose of the power factor correction? State the three power factor correction methods used in the industry.
 ii) Explain briefly, the methods of applying capacitors for the power factor correction.
 iii) Show that in a three phase system, the star connection requires a capacitor with a capacitance three times higher than the delta connected capacitor in order to supply the same reactive power.

[4 Marks]

- c) i) Explain briefly, what is an energy audit.
ii) What are the typical work steps of a Preliminary Energy Audit?

[3 Marks]

- Q4 a) i) What are the benefits of the energy demand forecasting?
ii) What are the techniques used for the energy demand forecasting?
iii) A cement industry with an initial load condition of 5400 kVA at a power factor of 60% has a consumption of 1,920,000 units per month supplied at 33 kV. It is desired to operate the plant at a power factor of 0.96.

Consider the tariff values as below.

Demand charges = Rs. 144/kVA per month

Energy charges = Rs. 4.11 per unit

Note: If the power factor is below 90%, an additional charge of 1% from both the demand charge and the energy charge is occurred for each 1% of power factor reduction.

- I. What size of capacitor bank in kVAr is required for the power factor improvement?
- II. Determine the cost saving due to the power factor improvement per year.
- III. Taking the cost of the capacitor bank as Rs. 2000/kVAr, the installation cost as Rs. 300,000 and the annual depreciation rate as 10%, determine the simple payback period.

[9 Marks]

- b) An energy efficient air compressor is proposed by a vendor. The compressor costs Rs. 30,000 for the installation and requires Rs. 1,000 of maintenance cost per year for a lifetime of 10 years. Rs. 6,000 per year is required as the energy cost of this energy efficient air compressor. But, a conventional standard air compressor only costs Rs. 25,000 and requires Rs. 500 of maintenance cost per year. Rs. 10,000 per year is required as the energy cost of the standard air compressor. If the company uses a discount rate of 10%, do you invest for this energy efficient air compressor?

[5 Marks]

- Q5 a) i) State four environmental impacts of the green house effect.
ii) Briefly explain the mitigation options to the green house effect.
iii) What is meant by the carbon sequestration? State the three carbon sequestration methods.

[6 Marks]

- b) i) Explain briefly, the main drawbacks of current energy model in Sri Lanka.
ii) Propose your own energy model for the energy sector in Sri Lanka and give the reasons why it is most suitable model compared to the present model.
[5 Marks]

- c) A coal-fired thermal power plant uses a coal type which consists 57.2% of Carbon, 2.2% of Hydrogen, 0.5% of Sulfur and 6.9% of Oxygen. Determine the percentage of the air quantity required to burn the coal. Air contains 23.2% of oxygen in weight.

State clearly, the assumptions you may use.

Hint: Mass number of Carbon = 12

Mass number of Sulfur = 32

Mass number of Oxygen = 16

Mass number of Hydrogen = 1

[3 Marks]