



**SCHOOL OF COMPUTING AND ENGINEERING SCIENCES
MASTER OF SCIENCE IN SUSTAINABLE ENERGY TRANSITIONS
END OF SEMESTER EXAMINATION**

MSSET 8202: ENERGY MANAGEMENT AND STANDARDS

DATE: 18th April, 2024

Time: 18:00-20:30 Hours

Instructions

1. This examination consists of **FOUR** questions.
2. Answer **Question ONE (COMPULSORY)** and any other **TWO** questions.

QUESTION ONE

(Total: 20 Marks)

- a. Motors and drives, pumps and pumping systems, heating ventilation and cooling (HVAC) systems, compressed air systems, building envelop system, boiler plant Systems, Refrigeration Systems and diesel generators are some of the major areas to look into when carrying out energy audits. Select one system from this list and answer the following questions;
 - i. Briefly explain the general concept of the system selected above. (1 Mark)
 - ii. Discuss the process of carrying out energy audit for the systems selected above. (3 Marks)
 - iii. Highlight major challenges that can be encountered when carrying out energy audits in this system. (2 Marks)
 - iv. Illustrate/discuss how you will evaluate the efficiency of this system. Use examples to illustrate. (3 Marks)
 - v. What are some of the conservation measures that can be taken to improve the efficiency of the chosen system? Discuss three of them. (3 Marks)
- b. A 9-watt light-emitting diode (LED) bulb produces the same light output as a 43-watt incandescent light bulb. Assuming an average daily bulb use of 3 hours per day and an average of 0.29 Kg of CO₂ emissions per kWh, determine carbon dioxide emissions reduced per light bulb by switched from an incandescent bulb to a light-emitting diode bulb. (3 Marks)
- c. A given water pumping station fills a tank at a fixed rate. The head and flow rate are constant and hence the power drawn by the pump is always same. The pump delivers 80 litres per second and the power consumption is measured as 84 kW. Calculate the energy consumption for pumping 2880 kL of water to the reservoir. (3 Marks)
- d. Explain two types of energy savings certificate as issued by the regulator EPRA. (2 Marks)

QUESTION TWO

(Total: 15 Marks)

- a. State two advantages of improvement of Power Factor at Load side (1 Mark)
- b. Why should power factor be corrected at the load? (2 Marks)
- c. An industrial plant has a demand of 50, 000 KW and operates at 80% power factor. The utility company supplying power to this unit requires minimum power factor of 90% and levies a KW demand charge of 30.00 in the electricity bill. Determine;
- The savings possible by improving the power factor to a minimum required target of 0.9. (7 Marks)
 - The payback period of putting any investment on power factor correction given a capacitor cost of 2000/KVAR for 480-volt system. (2 Marks)
- d. A 100 MW power station delivers 100 MW for 8 hours and 50 MW for 14 hours in a day and is shut down for maintenance for 45 days each year. Calculate its annual load factor (3 Marks)

QUESTION THREE

(Total: 15 Marks)

- a. Following an energy audit, an induced-draft fan was suggested to upgrade an industrial process. The motor to drive this fan is rated at 100 horsepower, and the motor will operate at full load for 8,760 hours per year. The motor's efficiency is 92%. Because the motor is fairly large, a demand charge of kshs 10,000 per kilowatt per year will be incurred in addition to an energy charge of kshs 30 per kilowatt-hour. If the installed cost of the motor is kshs 450,000, what is the net present worth of the motor over a 10-year period when the minimum acceptable rate of return (MARR) is 15% per year? (11 Marks)
- b. Discuss the four factors that influence energy efficiency in industrial and commercial settings. (4 Marks)

QUESTION FOUR

(Total: 15 Marks)

- a. When conducting an energy audit for a fresh juice production factory, the decision must be made regarding whether to focus on equipment efficiency or process efficiency improvement optimization. Discuss the considerations involved in making this decision, using an example to illustrate and approximate the total improvement achievable from both techniques. (4 Marks)
- b. Show in a chart and discuss where and how to save energy in an industry. (3 Marks)
- c. Calculate net present value for an investment towards an LED lighting. The following table gives investment and cash flow. (3 Marks)
- | | |
|------------------------|-----------------------|
| Investment: | Ksh.400/- |
| <i>Savings in year</i> | <i>Cash flow, Ksh</i> |
| Year # 1 | 1000 |
| Year # 2 | 1000 |
| Discount rate (k): | 10% |
| Life of the LED (t): | 2 years |
- d. Discuss the relationship between energy and the environment (*carbon emissions*) focusing on the role of energy audits in mitigating environmental impact. Provide examples and strategies for reducing carbon emissions through energy audit recommendations. (5 Marks)

Appendix

Calculation Table for Capacitor Selection

Power factor Cos θ_2 after improvement														
Power factor Cos θ_1 before improvement	1.0	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.85	0.80	
	0.5	1.73	1.59	1.53	1.48	1.44	1.40	1.37	1.34	1.30	1.28	1.25	1.11	0.98
	0.52	1.64	1.50	1.44	1.39	1.35	1.32	1.28	1.25	1.22	1.19	1.16	1.02	0.89
	0.55	1.52	1.38	1.32	1.27	1.23	1.19	1.16	1.12	1.09	1.06	1.04	0.90	0.77
	0.57	1.44	1.30	1.24	1.19	1.15	1.11	1.08	1.05	1.01	0.99	0.96	0.82	0.69
	0.6	1.33	1.19	1.13	1.08	1.04	1.01	0.97	0.94	0.91	0.88	0.85	0.71	0.58
	0.62	1.27	1.23	1.06	1.01	0.97	0.94	0.90	0.87	0.84	0.81	0.78	0.65	0.52
	0.65	1.17	1.03	0.97	0.92	0.88	0.84	0.81	0.77	0.74	0.71	0.69	0.55	0.42
	0.67	1.11	0.97	0.91	0.86	0.82	0.78	0.75	0.71	0.68	0.65	0.62	0.49	0.36
	0.7	1.02	0.88	0.81	0.77	0.73	0.69	0.66	0.62	0.59	0.56	0.54	0.40	0.27
	0.72	0.96	0.82	0.75	0.71	0.67	0.63	0.60	0.57	0.53	0.51	0.48	0.34	0.21
	0.75	0.88	0.74	0.67	0.63	0.58	0.55	0.52	0.49	0.45	0.43	0.40	0.26	0.13
	0.77	0.83	0.69	0.62	0.58	0.54	0.50	0.47	0.43	0.40	0.37	0.35	0.21	0.08
	0.8	0.75	0.61	0.54	0.50	0.46	0.42	0.39	0.35	0.32	0.29	0.27	0.13	
0.82	0.70	0.56	0.49	0.45	0.41	0.37	0.34	0.30	0.27	0.24	0.21	0.08		
0.85	0.62	0.48	0.42	0.37	0.33	0.29	0.26	0.22	0.19	0.16	0.14			
0.87	0.57	0.42	0.36	0.32	0.28	0.24	0.20	0.17	0.14	0.11	0.08			
0.90	0.48	0.34	0.28	0.23	0.19	0.16	0.12	0.09	0.06	0.02				
0.91	0.45	0.31	0.25	0.21	0.16	0.13	0.09	0.06	0.02					
0.92	0.43	0.28	0.22	0.18	0.13	0.10	0.06	0.03						
0.93	0.40	0.25	0.19	0.15	0.10	0.07	0.03							
0.94	0.36	0.22	0.16	0.11	0.07	0.04								
0.95	0.33	0.18	0.12	0.08	0.04									
0.96	0.29	0.15	0.09	0.04										
0.97	0.25	0.11	0.05											
0.98	0.20	0.06												
0.99	0.14													