SUPPLIMENTARY **Paper 1 – Set B**

Regn No: _____

Name : _____
(To be written by the candidate)

17th NATIONAL CERTIFICATION EXAMINATION FOR ENERGY MANAGERS & ENERGY AUDITORS – September, 2016

PAPER – 1: General Aspects of Energy Management & Energy Audit

Date: 24.09.2016 Timings: 0930-1230 HRS Duration: 3 HRS

General instructions:

- *Please check that this question paper contains **11** printed pages*
- *Please check that this question paper contains **64** questions*
- *The question paper is divided into three sections*
- *All questions in all three sections are compulsory*
- ***All parts of a question should be answered at one place***

Section – I: OBJECTIVE TYPE

1.	Which of these is not true of payback period a. Simple to calculate **b. Considers cash flow beyond the payback period** c. Shorter the period the better d. Does not take into account, time value of money
2.	Which of the following equipment is not covered under the mandatory schemes as per the S & L programme? a) household frost free refrigerators b) tubular fluorescent lamp c) **ceiling fans** d) room air conditioners
3.	Which is not an example of fuel substitution? a. **Replacement of Naptha by Natural gas as feedstock for fertilizer plant**. b. Replacement of coal by coconut shells. c. Replacement of LDO by LSHS d. Replacement of coconut shells by rice husk
4.	Which among the following is a green house gas? a) Sulphur Dioxide b) Carbon Monoxide c) NO_2 **d) Methane**
5.	What is the future value of Rs.1000/- after 3 years, if the interest rate is 10% a**) Rs. 1331** b) Rs.1610 c) Rs.3221 d) none of the above

6.	What is the expected power output in watts from a wind turbine with 6m diameter rotor, a coefficient of performance 0.45, generator efficiency 0.8,a gear box efficiency 0.90 and wind speed of 11m/sec a. 4875 watts b. 1100 watts **c. 7312 watts** d. 73.12 kW
7.	To judge the attractiveness of any investment, the energy auditor must consider a) Initial capital cost b) Net operating cash inflows **c**) salvage value **d) all the above**
8.	The time between its earliest and latest start time, or between its earliest and latest finish time of an activity is a) delay time b**) slack time** c) critical path d) start time
9.	The quantity of heat required to raise the temperature of a given substance by 1 ^{o}C is known as: a) sensible heat b) specific heat **c) heat capacity** d) latent heat
10.	The producer gas is basically **a. CO, H_2 and CH_4** b. Only CH_4 c. CO and CH_4 d. Only CO and H_2
11.	The Metric Tonne of Oil Equivalent (MTOE) value of 125 tonnes of coal having GCV of 4000 kcal/kg is a) 40 **b) 50** c) 100 d) 125
12.	The lowest theoretical temperature to which water can be cooled in a cooling tower is a. Difference between DBT and WBT of the atmospheric air b. Average DBT and WBT of the atmospheric air c. DBT of the atmospheric air **d. WBT of the atmospheric air**
13.	The kilowatt-hour is a unit of a) power **b) work** c) time d) force.
14.	The internal rate of return is the discount rate for which the NPV is a. Positive **b. Zero** c. Negative d. Less than 1
15.	The essential elements of monitoring and targeting system is a) Recording b) Reporting c) Controlling **d) All of the above**
16.	The energy intensity of countries that rely on import of carbon-intensive goods when compared with those producing it, would in all probability be a) Higher **b) Lower** c) Almost equald) No correlation
17.	The Energy Conservation Act requires that all designated consumers should get energy audits

	conducted by a) Energy Manager b) **Accredited energy auditor** c) Certified Energy Auditor d) Designated agencies
18.	The Critical Path in project planning technique indicates. a**) minimum time required for the completion of the project** b) delays in the project c) early start and late end of the project d) none of the above
19.	The "superheat" of steam is expressed as **a. degrees Centigrade above saturation temperature** b. critical temperature of the steam c. the temperature of the steam d. none of the above
20.	Liquid fuel density is measured by an instrument called a) Tachometer b) hygrometer c) anemometer **d) none of the above**
21.	ISO 50001:2011 provides a framework of requirements for organizations to: a) Develop a policy for more efficient use of energy b) Measure the results c) Fix targets and objectives to meet the policy **d) all of the above**
22.	Infrared thermometer is used to measure a) **Surface temperature** b) Flame temperature c) Flue gas temperature d) Hot water temperature
23.	In the material balance of a process or unit operation process, which component will not be considered on the input side? a) Chemicals b) Water/air c) Recycle **d) By product**
24.	In energy performance monitoring, 'Production Factor' means a) Current year Production / Design Capacity b) Reference Year Production / Current year Production **c)Current Year Production / Reference Year Production** d) CurrentYear Production / Previous Year Production
25.	In an industry the billed electricity consumption for a month is 5.8 lakh kWh. The fixed electricity consumption of the plant is 30000kWh and with a variable electricity consumption of 11 kWh/ton. Calculate the production of the industry a) **50000 tonnes** b**)** 60000 tonnes c) 58000 tonnes d) None of the above
26.	In project management, the critical path in the network is a) the quickest path b) the shortest path c) The path from start to finish **d) the path where activities have no slack**
27.	In a solar thermal power station , molten salt which is a mixture of 60% sodium nitrate and 40% potassium nitrate is used. It is preferred as it provides an efficient low cost medium to store _____

	a. Electrical energy **b. Thermal energy** c. Kinetic energy d. Potential energy
28.	In a cumulative sum chart if the graph is going up, it means **a. Energy consumption is going up** b. Energy consumption is going down c. Specific energy consumption is coming down d. No inference can be made
29.	In a coal fired boiler, hourly consumption of coal is 1300 kg. The ash content in the coal is 6%. Calculate the quantity of ash formed per day. Boiler operates 24 hrs/day. a) 216 kg b) 300 kg c) **1872 kg** d) none of the above
30.	In a chemical process two reactants A (300 kg) and B (400 kg) are used. If conversion is 50% and A and B react in equal proportions, the mass of the product formed is. **a) 300 kg** b) 350 kg c) 400 kg d) none of the above
31.	If the reactive power drawn by a particular load is zero it means the load is operating at a) Lagging power factor b**) Unity power factor** c) Leading power factor d) none of the above
32.	If Oxygen rich combustion air is supplied to a furnace instead of normal air the % CO_2 in flue gases will a) reduce b**) increase** c) remain same d) will become zero
33.	If a 2 KW immersion heater is used to heat 30litres of water at 30^{O}C, what would be the temperature of water after 15 minutes? Assume no losses in the system. a) 87.3 ^{O}C **b) 44.3^{O}C** c) 71.3 ^{O}C d) none of the above
34.	Identify from the following non-commercial energy. a. Wind b. Solar energy for water heating c. Solar energy for power generation **d. All the above**
35.	Having a documented energy policy in industry a) Satisfies regulations b) **Reflects top management commitment** c) Indicates availability of energy audit skills d) None of the Above
36.	Greenhouse effect is caused by natural affects and anthropogenic effects. If there is no natural greenhouse effect, the Earth's average surface temperature would be around _____°C. a) 0 b) 32 c) 14 **d) - 18**
37.	For every 10°C rise in temperature, the rate of chemical reaction doubles. When the temperature is increased from 30°C to 70°C, the rate of reaction increases _____ times. a) 8 b) 64 **c) 16** d) none of the above
38.	For energy consumption monitoring and target setting, it is imperative to have a) adequate metering b) accurate production data c) energy consumption data **d) all of the above**
39.	Doppler effect principle is used in the following instrument

	a) lux meter **b) ultrasonic flow meter** c) infrared thermometer d) flue gas analyzer
40.	Diagrammatic representation of input and output energy streams of an equipment or system is known as a) mollier diagram b) **sankey diagram** c) psychrometric chart d) balance diagram
41.	CUSUM technique can be used to identify a) deterioration in operating performance b) impact of good housekeeping & maintenance c) savings achieved by implementing energy conservation measure(s) d**) all of the above**
42.	Capital cost are associated with a) Design of Project b) Installation and Commissioning of Project c) Operation and Maintenance cost of project d) **both a and b**
43.	As per laws of thermodynamics; a) It is impossible to reduce the temperature of any substance to absolute zero b) Heat always flows from a hotter object to a colder object c) Energy conversion from one form to another cannot be 100% d) **All of the above**
44.	Any management would like to invest in projects with a**)** Low IRR b) Low ROI c) Low NPV of future returns **d) none of the above**
45.	Absolute pressure is a. Gauge pressure **b. Gauge pressure + Atmospheric pressure** c. Atmospheric pressure d. Gauge pressure - Atmospheric pressure
46.	A three phase induction motor is drawing 16 Ampere at 440 Volts. If the operating power factor of the motor is 0.90 and the motor efficiency is 92%, then the mechanical shaft power output of the motor is **a) 12.04 kW** b) 10.09 kW c) 10.97 kW d) None of the above
47.	A sling psychrometer is capable of measuring a) only dry bulb temperature b) only wet bulb temperature **c) both dry and wet bulb temperature** d) absolute humidity
48.	A process requires 10 Kg of fuel with a calorific value of 5000 kcal/kg. The system efficiency is 80% and the losses will be a**) 10000 kcal** b) 45000 kcal c) 500 kcal d) 2000 kcal
49.	A mass balance for energy conservation does not consider which of the following a. Steam b. water **c. Lubricating oil** d. Raw material

50.	A comparison of the trapping of heat by CO_2 and CH_4 is that **a) CH_4 traps 21 times more heat in the atmosphere than does CO_2** b) CO_2 traps 21 times more heat in the atmosphere than does CH_4 c) the same amount of heat is trapped by both CO_2 and CH_4 d) none of the above

……. End of Section – I ……..…

Section – II: SHORT DESCRIPTIVE QUESTIONS

S-1	**The average monthly electricity consumption in an Aluminium producing unit is 12.35 lac kWh. The other energy sources used in the manufacturing process are Furnace oil (GCV-9660 kcal/Ltr) and HSD (GCV-9410 kcal/Ltr). If the annual fuel oil consumption is 5760 kL of Furnace oil (sp. gr. 0.92) and 500 kL of HSD (sp. gr. 0.88), determine if the unit qualifies as a Designated Consumer under the EC Act?**
Ans	1 Mtoe = 1×10^7 kcal Annual electrical energy consumption = 12.35 x 12 = 148.2 lac Kwh Equivalent heat energy = $(148.2 \times 10^5 \times 860)/(1 \times 10^7)$ = 1274.52 Mtoe _(i) Annual Furnace oil consumption = 5760 kL Equivalent heat energy = $(5760 \times 1000 \times 9660)/(1 \times 10^7)$ = 5564.16 Mtoe _(ii) Annual HSD consumption = 500 kL Equivalent heat energy = $(500 \times 1000 \times 9410)/(1 \times 10^7)$ = 470.5 Mtoe _(iii) Total annual energy consumption = 1274.52 + 5564.16 + 470.5 = 7309.18 Mtoe To be a designated consumer, the minimum annual energy consumption (in aluminium sector) should be 7500 Mtoe. As the plant energy consumption doesn't exceed this threshold limit, it is not qualifies to be a designated consumer.
S - 2	**The annual fuel cost of boiler operation in a plant is Rs.8 Lakhs. The boiler with 65% efficiency is now replaced by a new one with 78% efficiency. What is the annual cost savings**?
Ans	Existing efficiency =65% Proposed efficiency=78% Annual fuel cost =Rs. 8 Lakhs Annual cost savings = annual fuel cost *(1-(Eff_O/Eff_N))

	= 8x((1-(0.65/0.78)) =Rs. 1,33,333.6 per annum
S-3	**In a textile manufacturing unit, wet cloth is dried in a stenter. The cloth entering the stenter has a moisture of 52% while that leaving the stenter is 96% dry. If the production rate (output) from the stenter is 200 Kg/hr, what is the quantity of steam required per hour, if the steam enters the stenter with an enthalpy of 660 kcal/kg. The condensate leaving the stenter is at 150^{o}C. Consider drying to take place at atmospheric pressure where the latent heat of water is 540 Kcal/Kg.**
Ans	Stenter output = 200 kgs/hr Bone dry cloth in output = 200 X 0.96 = 192 kgs. Moisture in output = 8 kgs. Moisture in input = 52% Bone dry cloth in input = 48% Total weight of input cloth = 192/0.48 = 400 kg/hr Quantity of water evaporated = 400 – 200 = 200 kg/hr Assuming sensible heat in steam at 150 ^{O}C = 150 kcal/kg Quantity of steam required = (200 X 540)/(660 – 150) = 211.8 kg/hr
S – 4	**A tank containing 500 kg of kerosene is to be heated from 10°C to 40°C in 20 minutes, using 4 bar (g) steam. The kerosene has a specific heat capacity of 2.0 kJ/kg °C over that temperature range. Latent heat of steam (hfg) at 4.0 bar g is 2 108.1 kJ/kg. The tank is well insulated and heat losses are negligible.** **Determine the steam flow rate in kg/hr.**
Ans	Q = 500 kg x 2 kJ/kg^{O}C x (40-10)^{O}C/(1200) = 25 kJ/sec Therefore mass of steam = 25 kJ/sec x3600 / 2108 .1 kJ/kg = 42.69 kg/h
S - 5	Explain how an ESCO model works.
Ans	ESCOs are usually companies that provide a complete energy project service, from assessment to design to construction or installation, along with engineering and project management services and financing. The ESCO will usually offer the following performance contract options. • Fixed fee • Shared Savings • Guaranteed savings ***(Note: Please refer page no: 177-179 of Paper 1, candidates can write relevant things about ESCO operation model)***
S-6	**Give relationship between Absolute and Gauge pressures. Give 4 different units used in pressure measurement**.
Ans	*Absolute pressure* is zero-referenced against a perfect vacuum, so it is equal to *gauge pressure* plus *atmospheric pressure*. *Gauge pressure* is zero-referenced against ambient *air pressure*, so it is equal to *absolute*

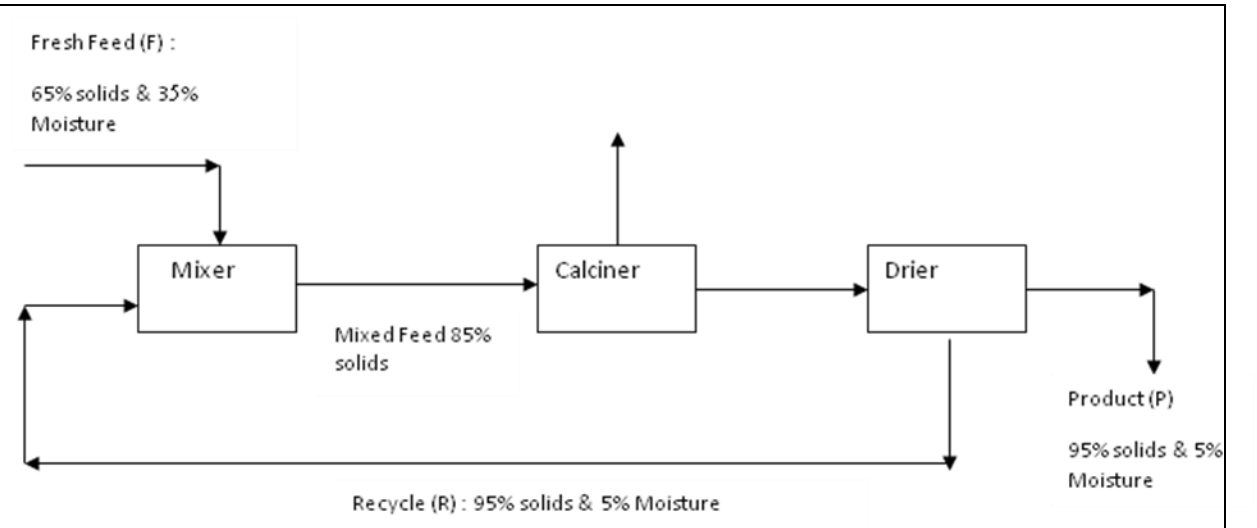
	pressure minus *atmospheric pressure*. (Negative signs are usually omitted) Absolute Pressure = Prevailing Atmospheric Pressure + Gauge Pressure (***NOTE: also please refer guide book-1 pg-70***) The four units of pressure measurement are: i) Pascal ii) kg / cm^2 iii) Atmospheric iv) mm of mercury v) Meters of water column vi) Pounds / $inch^2$ ***Note: any four of the above***
S-7	A plant is using 6 tonnes/day of coal to generate steam . The calorific of coal is 3300 kcal/kg. The cost of coal is Rs 4200/tonne . The plant substitutes coal with agro-residue , as a boiler fuel, which has a calorific value of 3100 kcal /kg and cost Rs.1800/tonne. Calculate the annual cost savings at 350 days of operation ,assuming the boiler efficiency remains same at 72% for coal and agro residue as fuel.
Ans	Useful energy to generate steam by 6 tonnes of coal per day = 6000 x 3300 x 0.72 = 14256000 kcal/day To deliver 14256000kcal/day , daily amount of rice husk required = 14256000 / (3100 x 0.72) =6387 kg/day Daily saving = (6000 / 1000) x 4200 - (6387 / 1000) x 1800 = 25200-11497 = Rs 13703/- Annual saving =13703 x 350 = Rs 47,96,050/-
S – 8	**What is meant by the following terms?** **a) Normalising of data** **b) Benchmarking**
Ans	a) Normalising of data The energy use of facilities varies greatly, partly due to factors beyond the energy efficiency of the equipment and operations. These factors may include weather or certain operating characteristics. Normalizing is the process of removing the impact of various factors on energy use so that energy performance of facilities and operations can be compared. b) Benchmarking Comparison of energy performance to peers and competitors to establish a relative understanding of where our performance ranks.

…… End of Section – II ……

Section – III: LONG DESCRIPTIVE QUESTIONS

L-1	**An integrated paper plant has produced 134241 MT of paper during the year 2012-13. The management has implemented various energy conservation measures as part of PAT scheme and reduced the specific energy consumption from 53 GJ/ tonne of product to 49 GJ/tonne of product. The actual production during the assessment year (2014-15) is 124141 MT. Calculate the plant energy performance and state your inference.**
Ans	Reference year production =134241 MT Reference year specific energy consumption = 53 GJ/tonne of product Assessment year production =124141 MT Assessment year specific energy consumption = 49 GJ/tonne of product $Production\ Factor = \frac{Assessment\ year's\ production}{Reference\ year's\ production}$ production factor = (124141 / 134241) = 0.92 $Reference\ year's\ energy\ consumption, GJ$ $= Reference\ year's\ specific\ energy\ consumption, \frac{GJ}{MT}\ X\ Reference\ year'sProduction, MT$ = 53 x 134241 = 7114773 GJ $Assessment\ year's\ energy\ consumption, GJ$ $= Assessment\ year's\ specific\ energy\ consumption, \frac{GJ}{MT}\ X\ Assessment\ year'sProduction, MT$ =49 x 124141 = 6082909 GJ $Reference\ year's\ equivalent\ energy\ use, GJ$ $= Reference\ year's\ energy\ consumption, GJ\ X\ Production\ factor$ = 7114773 GJ x 0.92 =6545591.16 GJ $Plant\ Energy\ performance, \% = \frac{Reference\ year's\ equivalent - Assessment\ years\ energy}{Reference\ year's\ equivalent\ energy}\ x\ 100$ = ((6545591.16 - 6082909) / 6545591.16)x 100 = 7.07% Inference : plant energy performance is positive and hence the plant is achieving energy savings.
L - 2	**Explain PAT Scheme and its potential impact?**
Ans	**Perform, Achieve and Trade (PAT) Scheme** is a market based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-

	intensive large industries and facilities, through certification of energy savings that could be traded. The key goal of PAT scheme is to mandate specific energy efficiency improvements for the most energy intensive industries. The scheme builds on the large variation in energy intensities of different units in almost every sector. The scheme envisages improvements in the energy intensity of each unit covered by it. The energy intensity reduction target mandated for each unit is dependent on its operating efficiency: the specific energy consumption reduction target is less for those who are more efficient, and is higher for the less-efficient units. Further, the scheme incentivizes units to exceed their specified SEC improvement targets. To facilitate this, the scheme provides the option for industries who achieve superior savings to receive energy savings certificates for this excess savings, and to trade the additional certified energy savings certificates with other designated consumers(energy intensive industries notified as Designated Consumers under the Energy Conservation Act and included under PAT Scheme) who can utilize these certificates to comply with their specific energy consumption reduction targets. Energy Savings Certificates (ESCerts) so issued will be tradable at Power Exchanges. The scheme also allows units which gain ESCerts to bank them for the next cycle of PAT, following the cycle in which they have been issued. The number of ESCerts which would be issued would depend on the quantum of energy saved over and above the target energy savings in the assessment year (for 1stCycle of PAT, assessment year is 2014-15). After completion of baseline audits, targets varying from unit to unit ranging from about 3 to 7% have been set and need to be accomplished by 2014-15 and after which new cycle with new targets will be proposed. Failing to achieve the specific energy consumption targets in the time frame would attract penalty for the non-compliance under Section 26 (1A) of the Energy Conservation Act, 2001 (amended in 2010). For ensuring the compliance with the set targets, system of verification and check-verification will be carried out by empanelment criteria of accredited energy auditors. ***NOTE: As the PAT scheme was not discussed in the 3rd edition, the evaluator may grant at least 5 marks to each candidate if this question was attempted, or more, if written well.***
L-3	**In a particular drying operation, it is necessary to hold the moisture content of feed to a calciner to 15% (W/W) to prevent lumping and sticking. This is accomplishing by mixing the feed having 35% moisture (w/w) with recycle steam of dried material having 5% moisture (w/w). The dryer operation is shown in fig below. What fraction of the dried product must be recycled?**



Ans

Let

F indicate quantity of feed

R indicate quantity of recycle

P indicate quantity of product

Based on solid content at Mixer

0.65F + 0.95R = 0.85 (F + R)

Hence R =2 F ……..(1)

Based on solid content at Drier

0.85 (F + R) = 0.95 (P + R)

0.85 (F + 2F) = 0.95 P + (0.95 x 2 F)

2.55 F = 0.95 P + 1.9 F

0.65 F = 0.95 P

Hence F = 1.46 P ……(2)

Substituting (2) in (1) for obtaining Recycle quantity in terms of Product

R = (2.0 x 1.46 P) = 2.92 P ……..(3)

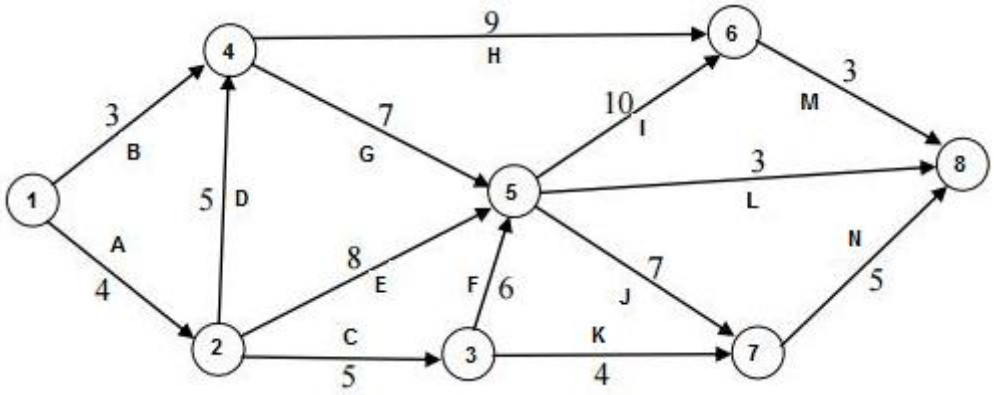
Product plus Recycle is

P + R = (P + 2.92 P) = P(1 + 2.92) = 3.92 P …..(4)

R (as a fraction of dried product) = {(2.92 P) / (3.92 P)} x (100)
= 74.49%

L - 4 **a) Why do project managers give a great degree of attention to critical path?**

b) For the PERT diagram with duration of activities shown, determine the following:

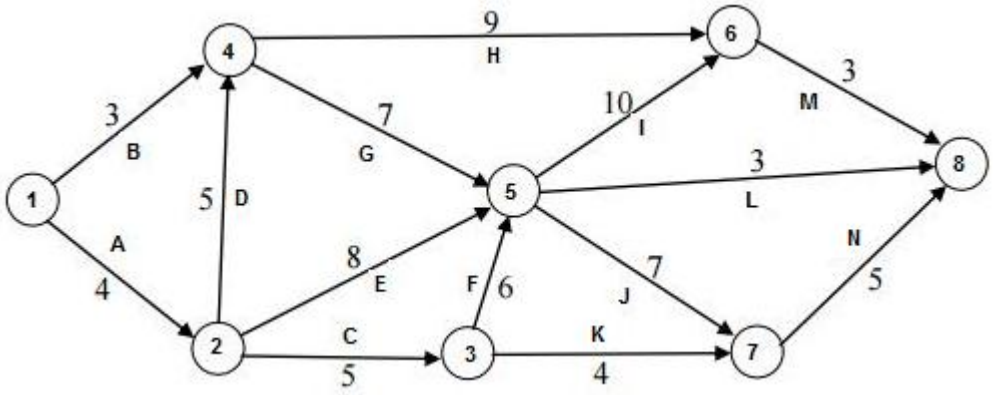


1. **What is the shortest time for completion of the project?**
2. **Which activities must be completed on time in order for the project to finish in the shortest possible time?**

Ans

a) The critical path is of great interest to project managers. The activities on the critical path are the ones which absolutely must be done on time in order for the whole project to complete on time. If any of the activities on the critical path are late, then the entire project will finish late.

b)



Activity	Duration (weeks)	ES	EF	LS	LF	Slack	Critical path
A	4	**0**	**4**	**0**	**4**		**Yes**
B	3	0	3	6	9		
C	5	4	9	5	10		
D	5	**4**	**9**	**4**	**9**		**Yes**
E	8	4	12	8	16		
F	6	9	15	10	16		
G	7	**9**	**16**	**9**	**16**		**Yes**

H	9	9	18	17	26		
I	10	**16**	**26**	**16**	**26**		**Yes**
J	7	16	23	17	24		
K	4	9	13	20	24		
L	3	16	19	26	29		
M	3	**26**	**29**	**26**	**29**		**Yes**
N	5	23	28	24	29		

1. The shortest time to complete project – 29 weeks
2. Critical path : A - D - G - I – M

L -5

A 20 kW, 415V, 38A, 4 pole, 50 Hz, 3 phase rated squirrel cage induction motor has a full load efficiency and power factor of 88% and 0.85 respectively. An energy auditor measures the following operating data of the motor.

1) **Supply voltage= 408V**
2) **Current drawn= 28A**
3) **PF=0.83**

.Find out the following at motor operating conditions.

1) **Power input in kW**
2) **% motor loading**

b) List five energy saving measures in your home

Ans

a) 1) Power input = 1.732*408*28*0.83
= 16.42 kW

2) % motor loading = [16.42/(20/0.88)]*100
= (16.42/22.73)
= 72.24%

b)

- Replacement of inefficient electric lamps with efficient electric lamps
- Using star labeled household appliances like A/c's, Refrigerator,Lamps,Fans
- Using Solar water heating systems for hot water requirements to minimize use of electric geysers
- Using Solar PV systems for electricity generation
- Proper ventilation maximizing the use of natural light
- Switching off all equipment when not required
- Using pressure cooker for cooking food
- Maximizing the use of low fire burner (SIM) in the gas stove
- Using A/Cs at setpoint of 21^{o}C-23^{o}C instead of 16^{o}C
- Placing the fridge so that the rear (condenser coils) are located where there is proper air flow.

Note : Any five of the above and also give marks for other relevant options

L-6

An investment of Rs.250,000 is being considered for an energy efficient equipment.The cost of capital for the investment is 13%.Following cash flows are expected from the investment:

Year	Rs.

0	(250,000)
1	50,000
2	100,000
3	200,000

1) Calculate the IRR for the proposed investment and interpret your answer.

Ans

Step 1: Select 2 discount rates for the calculation of NPVs
We can take 10% (R1) and 20% (R2) as our discount rates.

Step 2: Calculate NPVs of the investment using the 2 discount rates
Net Present Value @ 10%

Cash Flow A	Discount Factor B	Present Value AxB
(250,000)	1.000	(250,000)
50,000	0.909	45,450
100,000	0.826	82,600
200,000	0.751	150,200
	NPV1	28,250

Net Present Value @ 20%

Cash Flow A	Discount Factor B	Present Value AxB
(250,000)	1.000	(250,000)
50,000	0.833	41,650
100,000	0.694	69,400
200,000	0.57	115,800
	NPV2	-23,150

Step 3: Calculate the IRR

$$\text{Internal Rate of Return} = R1\% + \frac{NPV1 \times (R2 - R1)\%}{(NPV1 - NPV2)}$$

$$= 10\% + \frac{28{,}250 \times (20 - 10)\%}{(28{,}250 - (-3{,}150))}$$

$$= 10\% + \frac{28{,}250 \times 10\%}{28{,}250 + 23{,}150}$$

$$= 10\% + 5.5\%$$

$$= 15.5\%$$

……. End of Section – III ……