

BEE 2026 Sample Paper — Paper-3

Energy Efficiency in Electrical Utilities

Full exam pattern: **Section I** 50 objective $\times 1 = 50$ · **Section II** 8 short $\times 5 = 40$ · **Section III** 6 long $\times 10 = 60$ · **Total 150, pass mark 75, 3 hours.**

Every question is a real BEE past-paper question with the official answer, chosen by chapter weightage and how often the examiner has repeated it (42 of the 64 have appeared in two or more exams). Sit it like the real thing: start the timer, answer Section I without notes, then write Sections II and III on paper before opening the model answers.

Section I — Objective type (50 $\times$ 1 = 50 marks)

Answer all 50. One mark each, no negative marking.

1. If V_1 is actual supply voltage and V_2 is the rated voltage of a capacitor, the reactive kVAR produced would be in the ratio of

a) V_1^2/V_2^2

b) V_1^2/V_2

c) $1 - V_1^2/V_2^2$

d) $1 + V_1^2/V_2^2$

2. Which of the following is not a part of vapour compression refrigeration cycle ?

a) Compressor

b) Evaporator

c) Condenser

d) Generator

3. In a transformer on load, if the secondary voltage is one-fourth the primary voltage, then the secondary current will be

- a) four times the primary current
- b) sixteen times the primary current
- c) one-fourth the primary current
- d) two times the primary current

4. A DG set is consuming 70 litres per hour diesel oil. If the specific fuel consumption is 0.33 litres/kWh, what is the kVA loading at 0.8 power factor ?

- a) 212 kVA
- b) 265 kVA
- c) 170 kVA
- d) none of the above

5. If 30,000 kcal of heat is removed from a room every hour then the refrigeration tonnage will be nearly equal to

- a) 30 TR
- b) 15 TR
- c) 10 TR
- d) 100 TR

6. During a leak test of a compressed air system, the compressor's average load time was 1.5 minute, average unload time was 10.5 minutes and flow rate was 35 m³/min. The leakage quantity is

- a) 4.375
- b) 5.125
- c) 7.625
- d) 6.250

7. L / G ratio in a cooling tower is the ratio of _____.

- a) Length and girth
- b) Length and Temperature gradient
- c) Water flow rate and air mass flow rate
- d) Air mass flow rate and water flow rate

8. In a DG set, a 3-phase alternator is supplying on an average 100 A at 420 V and 0.9 pf to a load. If the specific fuel consumption of this DG set is 0.30 lit/kWh at that load, then how much fuel is consumed while delivering generated power for one hour?

- a) 11.34 litre
- b) 19.64 litre
- c) 21.82 litre
- d) 65.50 litre

9. A process fluid at 40 m³/hr, with a density of 0.95, is flowing in a heat exchanger and is to be cooled from 35 °C to 29 °C. The fluid specific heat is 0.78 kCal/kg. The chilled water range across the heat exchanger is 4 °C, the chilled water flow rate is

- a) 44.46 m³/hr
- b) 40.41 m³/hr
- c) 35.37 m³/hr
- d) none of the above

10. Increasing the cycles of concentration of circulating water in a cooling tower will

- a) increase blow down quantity
- b) decrease blow down quantity
- c) increase drift losses
- d) decrease fan power consumption

11. A package air conditioner of 5 TR capacity delivers a cooling effect of 4 TR. If Energy Efficiency Ratio (W/W) is 2.90, the power in kW drawn by compressor would be:

a) 4.84

b) 1.38

c) 1.724

d) None of the above

12. If the power consumed by an air conditioner compressor is 1.7 kW per ton of refrigeration, then its energy efficiency ratio (Watt/Watt) is _____

a) 1.7

b) 2.06

c) 0.59

d) none of the above

13. A fan is drawing 16 kW at 800 RPM. If the speed is reduced to 600 RPM then the power drawn by the fan would be

a) 12 kW

b) 9 kW

c) 6.75 kW

d) None of the above

14. Which of the following is not likely to create harmonics in an electrical system?

a) soft starters

b) variable frequency drives

c) uninterrupter power supply source (UPS)

d) electric heater

15. A 5 kVAr, 415 V rated power factor capacitor was found to be having 5.5 kVAr operating capacity. The operating supply voltage at the same supply frequency would be approximately.

- a) 400 V
- b) 415 V
- c) 435 V
- d) None of the above

16. Power factor is highest in case of

- a) sodium vapour lamps
- b) LED lamps
- c) tube lights
- d) incandescent lamps

17. In which of the following fans the air does not change flow direction from suction to discharge?

- a) tube axial fan
- b) vane axial fan
- c) propeller fan
- d) all the above

18. A hotel building has four floors each of 1000 m² area. If the Lighting Power Density (LPD) is 10.8 W/m², the interior lighting power allowance for the hotel building is _____.

- a) 1000 W
- b) 21600 W
- c) 43200 W
- d) none of the above

19. The source of maximum harmonics among the following, in a plant power system is

- a) 100 CFL lamps of 11 W to 25 W
- b) 500 kW, 3 Phase, 415 V, 50 Hz resistance furnace
- c) 5 kVA UPS for computer system
- d) variable frequency drive for 225 kW motive load

20. Which of the following type of lamps is most suitable for color critical applications?

- a) halogen lamps
- b) LED lamps
- c) CFLs
- d) Low pressure sodium vapour lamp

21. Which of the following compressors do not use loading / un-loading method for capacity control?

- a) screw compressor
- b) centrifugal compressor
- c) reciprocating compressor
- d) all of the above

22. In T-5 Fluorescent Lamp, '5' is indicative of:

- a) 5 watt power rating
- b) 5% energy saving with respect to T8
- c) 5/8 generation lamp
- d) Tube diameter

23. The Solar Heat Gain Co-efficient (SHGC) of a window of a building is 0.30. This means

- a) The window allows 70% of the sun's heat to pass through into interior of the building
- b) The window allows 30% of the sun's heat to pass through into the building interior
- c) 70% of the sun's heat is incident on the window
- d) The window reflects back to exterior a minimum of 30 % of the sun's heat

24. _____ is used to capture water droplets in the air stream leaving the cooling tower.

- a) Splash fill
- b) Film fill
- c) Drift eliminator
- d) Any of the above

25. Which of the following equipment is having least compression ratio?

- a) Compressor
- b) Blower
- c) Axial Fan
- d) Radial Fan

26. The adsorption material used in an adsorption air dryer is

- a) Calcium chloride
- b) Magnesium chloride
- c) Activated alumina
- d) Potassium chloride

27. In a vapor compression refrigeration system, the component across which the enthalpy remains constant

- a) compressor
- b) condenser
- c) expansion valve
- d) evaporator

28. Lower power factor of a DG set demands _____.

- a) lower excitation currents
- b) no change in excitation currents
- c) higher excitation currents
- d) none of the above

29. The unit of AAEPI is given by _____

- a) kWh/m²/yr
- b) x kWh/hr
- c) (Wh/m²)/hr
- d) m³/Wh/yr

30. A super thermal power station of 2500 MW installed capacity generated 14,000 million units in a year. It's annual Plant Load Factor (PLF) is _____.

- a) 60%
- b) 79%
- c) 64%
- d) none of the above

31. The percentage reduction in distribution losses when tail end power factor is raised from 0.8 to 0.95 is _____.

- a) 29%
- b) 15.8%
- c) 71%
- d) none of the above

32. In which of the following fans air enters and leaves the fan with no change in direction ?

- a) Forward curved
- b) Backward curved
- c) Radial
- d) Propeller

33. ECBC code is applicable to commercial buildings having connected load of _____.

- a) 100 kW
- b) 500 kW
- c) 250 kW
- d) 1000 kW

34. The purpose of inter-cooling in a multistage compressor is to

- a) Increase the pressure of air
- b) Reduce the work of compression
- c) Separate moisture and oil vapour
- d) None of the above

35. In an engine room 15 m long, 10 m wide and 4 m high, ventilation requirement for 20 air changes/hr is ____ m³/hr

- a) 30
- b) 3000
- c) 12000
- d) none of the above

36. A pump with 230 mm diameter impeller is delivering a flow of 150 m³/hr. If the flow is to be reduced to 110 m³/hr by trimming the impeller, what should be the approximate impeller size?

- a) 195 mm
- b) 175 mm
- c) 169 mm
- d) 207 mm

37. What is window to wall ratio _____

- a) Vertical fenestration area / gross exterior wall area
- b) Vertical fenestration area / Net exterior wall area
- c) gross exterior wall area/ Vertical fenestration area
- d) Net exterior wall area/ Vertical fenestration area

38. If a 200 cfm compressor is pressurized (on load) in 10 seconds and unloads in 20 seconds during a leakage test, the air leakage would be _____.

- a) 67 cfm
- b) 100 cfm
- c) 10 cfm
- d) 133 cfm

39. The blow down loss in a cooling tower depends on

- a) TDS in circulating water
- b) TDS in make-up water
- c) evaporation loss
- d) all the above

40. Capacitors with automatic power factor controller when installed in a plant:

- a) reduces apparent power drawn from grid
- b) reduces the voltage of the plant
- c) reduces the reactive power drawn from grid
- d) increases the load current of the plant

41. Friction losses in a pumping system is

- a) inversely proportional to flow
- b) inversely proportional to cube of flow
- c) proportional to square of flow
- d) inversely proportional square of flow

42. Which of the following statements is not true regarding centrifugal pumps?

- a) Flow is zero at shut off head
- b) Maximum efficiency will be at design rated flow of the pump
- c) Head decreases with increase in flow
- d) Power increases with throttling

43. Increasing the suction pipe diameter in a pumping system will

- a) Decrease NPSHA
- b) Increase NPSHA
- c) Decrease NPSHR
- d) Increase NPSHR

44. The performance of winding of an induction motor can be assessed by which of the following factors?

- a) load current
- b) stator resistance
- c) no load current
- d) both b and c

45. Use of soft starters for induction motors results in

- a) lower mechanical stress
- b) lower power factor
- c) higher maximum demand
- d) All the above

46. Which gas is used as refrigerant both in vapour compression and vapour absorption systems

- a) Lithium Bromide
- b) Water
- c) HFC 134A
- d) Ammonia

47. Adsorption drying of air is achieved using _____.

- a) Activated alumina
- b) Carbon Molecular Sieves
- c) Zirconium Molecular Sieves
- d) None of the above

48. The inexpensive way to improve energy efficiency of a motor which operates consistently at below 40% of rated capacity is by ____

- a) Operating in Star mode
- b) Replacing with correct sized motor
- c) Operating in delta mode
- d) Operating in VFD mode

49. A pump discharge has to be reduced from 120 m³/hr to 100 m³/hr by trimming the impeller. What should be the percentage reduction in impeller size?

- a) 83.3%
- b) 16.7%
- c) 50.0%
- d) 33.3%

50. Which of the following is not true regarding system characteristic curve in a pumping system with large dynamic head?

- a) System curve represents a relationship between discharge and head loss in a system of pipes
- b) System curve is dependent on the pump speed
- c) The basic shape of a system curve is parabolic
- d) System curve will start at zero flow and zero head if there is no static lift

Section II — Short answer type ($8 \times 5 = 40$ marks)

Answer all questions. Write the formula line with units first — step marks are given even if the arithmetic slips.

- S1** Compute AT&C (Aggregate Technical and Commercial) Losses for the given data: Input Energy $E_i=20$ MU, Energy Billed Metered $E_1=16$ MU, Un-metered $E_2=1$ MU, Total Billed $E_b=17$ MU, Amount Billed $A_b=\text{Rs.}800$ lakhs, Gross Amount Collected $A_g=\text{Rs.}820$ lakhs, Arrears Collected $A_r=\text{Rs.}40$ lakhs.
- S2** A multi storied office has centralized air conditioning system by using the chilled water. The chilled water inlet and outlet temperatures are 13°C and 9°C respectively. The chilled water pump discharge pressure is $4.2 \text{ kg/cm}^2\text{g}$ and the suction is 10 meters above the pump centerline. The power drawn by the chilled water pump's motor is 75 kW and an efficiency of 92%. The chilled water pump efficiency at the operating point from pump characteristic curve is 65%. Find out the operating refrigeration load in TR.
- S3** List five energy saving measures in compressed air system.
- S4** A process plant is situated 100 m up the side of the hill. The plant requires 100 kL of water per hour. The management decides to install a pump at the ground level, with suction 3 metre below the ground level. The friction head is 12 metre. Evaluate the rating of the motor required considering 10% extra margin with respect to actual input pump power. The design pump efficiency is 65% and motor efficiency 93%.
- S5** Estimate the cooling tower capacity (TR) and approach: water flow $2 \text{ m}^3/\text{min}$, specific heat $1 \text{ kcal/kg}^\circ\text{C}$, inlet water 43°C , outlet water 35°C , ambient WBT 30°C .
- S6** Find out the Effective Aperture (EA) of the following two glazing and comment about compliance with ECBC. Case #1: Window to Wall Ratio (WWR) 0.2, Visible Light Transmittance (VLT) Transparent (perfectly clear glass, i.e. $\text{VLT} = 1.0$). Case #2: Window to Wall Ratio (WWR) 0.45, Visible Light Transmittance (VLT) 0.2.

S7 A V-belt driven centrifugal fan is supplying air to a chemical process. Calculate the fan static efficiency for the following operating parameters: Ambient temperature 40degC; Density of air 1.127 kg/m³; Diameter of discharge air duct 1 meter; Velocity pressure measured by Pitot tube in discharge duct 47 mm WC; Pitot tube coefficient 0.9; Static pressure at fan inlet -22 mm WC; Static pressure at fan outlet 188 mm WC; Power drawn by motor 72 kW; Belt transmission efficiency 95%; Motor efficiency at operating load 90%.

S8 A 5 MW DG set running at 70% load for base load operation generates 8.6 kg of exhaust gas per kWh. The exhaust gas is reduced to 200oC. The specific heat of flue gas is 0.26 kcal/kg-oC. The steam generated from waste heat boiler will be used in double effect Li-Br Vapour Absorption Chiller with a COP of 1.12. How much TR will be generated through VAM? (5 Marks)

Section III — Long answer type (6 × 10 = 60 marks)

Answer all questions. Write the formula line with units first — step marks are given even if the arithmetic slips.

L1 A review of electricity bills of a process plant was conducted as a part of energy audit. The plant has a contract demand of 3000 kVA with the power supply company. The average maximum demand of the plant is 2400 kVA/month at a power factor of 0.95. The maximum demand is at 80% of the contract demand. The minimum billable maximum demand is 80% of the contract demand. An incentive of 0.5 % reduction in energy charges component of electricity bill are provided for every 0.01 increase in power factor over and above 0.95. The average energy charge component of the electricity bill per month for the plant is Rs.80 lakhs. Calculate the following: a) If the plant decides to improve the power factor to unity, determine the power factor capacitor kVAR required and the associated monetary benefits. b) What will be the simple payback period if the cost of power factor capacitors is Rs.1200/kVAR.

L2 a) Calculate the filter area of an Air Handling Unit (AHU) for Refrigeration Load of 50 TR. The air enthalpy at inlet of AHU is 85 kJ/kg and at outlet is of 60 kJ/kg. Air velocity at filter is 1.81 m/sec and air density is 1.26 kg/m³. (5 Marks) b) A no load test was conducted in a delta connected 37 kW induction motor. Name plate data: 3 Phase, 415 V, 50 Hz, 55 Amp. Measured data on no load: Voltage V = 415 Volts; Current I = 18 Amps; Frequency F = 50 Hz; Stator phase resistance at no load = 0.23 Ohms/phase. No load power = 955 Watts. Calculate: i. The iron loss plus friction loss plus windage loss (2 Marks) ii. Stator copper loss at name plate ratings (full load), considering stator temperature as 120°C (2 Marks) iii. No load power factor of the motor (1 Mark)

L3 In a steel industry, cooling water of 7500 m³/hr and 4200 m³/hr from two different sections with temperatures of 38 °C and 55 °C respectively, are fed to cooling tower after proper mixing. If the measured heat rejection by the cooling tower is 38,000 TR, calculate the effectiveness and evaporation loss of the cooling tower at 28 °C WBT.

L4 Rated capacity of a fresh water shut-discharge pump flow rate is 485 m³/hr and discharge pressure is 13.5 kg/cm² at rated speed of 2950 rpm. It has been observed that 450 m³/hr water is sufficient to dispose the ash. The suction pressure of the pump is 0.5 kg/cm². The management has decided to trim the impeller to satisfy the reduced flow requirement. Calculate: a) % reduction of impeller diameter (5 Marks) b) Annual energy savings after modification, if the pump is operating for 6 hours/day and 330 days in a year. (5 Marks)

L5 L-6: An engineering industry operating three shifts per day has replaced its old reciprocating compressors with 1000 CFM screw compressors. During the energy audit, run hours counter readings: Load Hours start 7956, end 8401 (166 Loading kW); Un-Load Hours start 4918, end 5121 (58.1 un-loading kW). Calculate: 1. Capacity Utilization (%) of the compressor; 2. Monthly energy consumption for the present loading of the compressor; 3. Plant management is considering to install a 750 CFM compressor for energy savings. Estimate the energy savings for the same operating load, if loading power is 125 kW and unloading power is 43.75 kW; 4. To meet the present air requirement, if VFD is to be installed in the 1000 CFM compressor, what should be the percentage reduction in speed.

L6 L3 a) Match the following: (4 Marks)

1 Prescriptive Approach

2 Whole Building Performance Approach

3 Building envelope

4 Effective Aperture

Options:

1. Exterior façade

2. Trade-Off option

3. light admitting potential

4. Uses simulation to show compliance for the entire building

b. Fill in the following blank statements:

1. The Effective Aperture (EA) or light admitting potential of a glazing system is determined by multiplying the Visible Light Transmittance (VLT) of the glazing by the ____ of the building.

2. Thermal emittance is the relative ability of a material to ____ the absorbed heat.

3. If a window has a SHGC of 0.25 and the total incident solar radiation is 600 W/m^2 , the solar heat gain through the window is ____

4. The emissivity of a material is the ratio of energy radiated by a particular material to energy radiated by a ____ at the same temperature.

5. As per ECBC the unit of Energy Performance Index (EPI) ____

6. Fenestration surface having a slope of less than 60 degrees from the horizontal plane is termed ____ (6 Marks)

Answer Key

Section I

- 1 **A** Confirmed vs Book-3 §1.4 Voltage effects — capacitor output varies with the square of the applied voltage, so the kVAr actually produced is in the ratio V_1^2/V_2^2 of the rated value (V_1 = actual, V_2 = rated).
Option (c) 1
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- 2 **D** The vapour compression circuit has exactly four elements: compressor, condenser, expansion device and evaporator.
The GENERATOR (along with the absorber, solution pump and solution heat exchanger) belongs to the vapour a
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- 3 **A** Confirmed vs Book-3 §1.5 — 'Primary ampere-turns are equal to secondary ampere-turns', so $V_1 I_1 = V_2 I_2$. With $V_2 = V_1/4$, the secondary current must be four times the primary current.
Option (c) is the trap: current and vol
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- 4 **B** Confirmed vs Book-3 §9.4 — kW = $70/0.33 = 212.1$ kW; kVA = $212.1/0.8 = 265$ kVA. Option (a) 212 kVA is the kW figure; (c) 170 comes from multiplying by PF instead of dividing.
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- 5 **C** Confirmed vs Book-3 §4.7 - 1 TR = 3024 kcal/hr (book value). TR = $30000/3024 \approx 9.92 \approx 10$ TR.
Option (a) 30 TR forgets to divide by 3024 and (b) 15 TR halves it; $30,000/3024 = 9.92$, which rounds to 10 TR.
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- 6 **A** Confirmed vs Book-3 §3.5 Avoiding Air Leaks — This is the book's worked leakage example: $q = T/(T+t) \times Q = 1.5/(1.5+10.5) \times 35 = 0.125 \times 35 = 4.375$ m³/min, i.e. 6300 m³/day.
The other options arise from using the unload
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- 7 **C** L over G, in that order: L = water (liquid) mass flow, G = gas (air) mass flow. Option (d) reverses the ratio and is the trap — check which term is on top before ticking. Against design values, seasonal tuning of water b
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- 8 **B** Confirmed vs Book-3 §9.2/§9.4 — Power = $\sqrt{3} \times 420 \times 100 \times 0.9 = 65,466$ W = 65.47 kW; fuel = $65.47 \times 0.30 = 19.64$ litres per hour. (c) 21.82 L ignores the 0.9 PF; (d) 65.50 is the kW value mis-read as litres.
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- 9 **A** Confirmed vs Book-3 §4.7 - Heat load = $40 \times 0.95 \times 1000 \times 0.78 \times (35-29) = 177840$ kcal/hr; chilled water flow = $177840/(1000 \times 1 \times 4) = 44.46$ m³/hr. Option (b) copies the process flow rate; the chilled-water flow must carry the same
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- 10 **B** Confirmed vs Book-3 §7.2 (vii) — Blow Down = Evaporation/(COC - 1); a higher COC lowers the blowdown quantity → (b). Drift loss is set by the eliminators and air velocity, and fan power by air flow – neither depends on C
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- 11 **A** Confirmed vs Book-3 §4.9 - Cooling delivered = 4 TR = $4 \times 3.51 = 14.04$ kW. Power = cooling/EER = $14.04/2.90 = 4.84$ kW. Option (b) 1.38 divides by 2.9 twice and (c) 1.724 uses the

5 TR nameplate; use the DELIVERED 4 TR =

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- 12 **B** Confirmed vs Book-3 §4.9 - EER = cooling/power = 3.517 kW per TR / 1.7 kW = 2.06 W/W.
Option (a) 1.7 just repeats the input figure and (c) 0.59 inverts it; EER = 3.517 kW of cooling per TR divided by 1.7 kW input = 2.06
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- 13 **C** Power $\propto N^3$: $16 \times (600/800)^3 = 16 \times 0.75^3 = 16 \times 0.4219 = 6.75$ kW. The two wrong options are exactly the two classic errors — 12 kW is N^1 (treating power like flow) and 9 kW is N^2 (treating power like pressure). Chant it:
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- 14 **D** Confirmed vs Book-3 §1.10 — the book classes heaters as LINEAR loads ('Incandescent lamps, heaters and, to a great extent, motors are linear systems') because their impedance is constant, so they draw a sinusoidal current
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- 15 **C** Confirmed vs Book-3 §1.4 — $kVar \propto V^2$, so $V = 415 \times \sqrt{(5.5/5)} = 415 \times 1.0488 \approx 435$ V.
Option (a) 400 V would REDUCE the output below 5 kVar; a higher-than-rated output always means a higher-than-rated terminal voltage (which)
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- 16 **D** Confirmed vs Book-3 §8.3 — An incandescent lamp is a plain heated filament, a purely resistive load, so its power factor is ~ 1 . Sodium vapour lamps and tube lights need inductive ballasts/ignitors (§8.2 control gear) and
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- 17 **D** Confirmed vs Book-3 §5.2 — Tube-axial, vane-axial and propeller are all axial-flow fans, in which 'air enters and leaves the fan with no change in direction' $\rightarrow$ all the above (d). Only centrifugal fans turn the airflow (turn)
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- 18 **C** Confirmed vs Book-3 §8.2 (power density) — Allowance = area $\times$ LPD = $(4 \times 1000 \text{ m}^2) \times 10.8 \text{ W/m}^2 = 43,200$ W. 21,600 W would be two floors; 1000 W ignores the LPD.
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- 19 **D** Confirmed vs Book-3 §1.10 — VFDs head the book's list of non-linear loads, and the harmonic current injected scales with the load, so a 225 kW drive is by far the biggest source here. Option (b) is the trap: a 500 kW resistor
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- 20 **A** Confirmed vs Book-3 §8.3 Table 8.1 — Halogen CRI = Excellent (100), LED 80, CFL 85, LPSV Poor (10 — monochromatic, colours appear grey). Colour-critical work needs the highest CRI, so halogen.
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- 21 **B** Confirmed vs Book-3 §3.5 Capacity Control of Compressors (Tables 3.13 & 3.14) — Load/unload (two-step) and multi-step unloading are the control schemes the book describes for positive-displacement machines — reciprocating
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- 22 **D** Confirmed vs Book-3 §8.3 — T5 means a tube of 5/8 inch (16 mm) diameter; T8 = 1 inch (25 mm), T12 = 1.5 inch (38 mm). The number is neither wattage nor a saving percentage (the book's 5 % figure is the T5/T8 efficacy gain)
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- 23 **B** Confirmed vs Book-3 §10.5 — SHGC is the fraction of incident solar radiation that passes through the fenestration as heat; SHGC 0.30 means 30% of the sun's heat enters the interior (Figure 10.4: SHGC 0.39 $\rightarrow$ 39% transmittance)
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- 24 **C** Confirmed vs Book-3 §7.1 Components — Book: drift eliminators 'capture water droplets entrapped in the air stream' → (c). Splash and film fill are heat-transfer media, not droplet catchers.
- 25 **C** Confirmed vs Book-3 §5.1/§5.4 — Compression (specific) ratio: compressors $> 1.20 >$ blowers $1.11\text{--}1.20 >$ fans ≤ 1.11 ; and among fans 'axial-flow fans produce lower pressure than centrifugal fans' (radial fans reach up to 1
- 26 **C** Confirmed vs Book-3 §3.5 Air Dryers (Tables 3.18 & 3.19) — Book-3 names activated alumina and silica gel as the common adsorbents for compressed air drying; they bind moisture physically on a large porous inner surface a
- 27 **C** Confirmed vs Book-3 §4.3 - Expansion (throttling) is an isenthalpic process; enthalpy remains constant across the expansion valve. Enthalpy rises in the evaporator (d) and compressor (a) and falls in the condenser (b); §
- 28 **C** Confirmed vs Book-3 §1.4/Ch-9 — an alternator supplies the load's reactive kVAr from its field; the lower the power factor, the larger the kVAr for the same kW, so the field (excitation) current must be increased.
Option
- 29 **C** Confirmed vs Book-3 Ch-10 (ECBC / building energy index) - Air conditioning Annual Energy Performance Index is expressed as Wh per m² per hour. Options (a), (b) and (d) mix up units used for building EPI and volumetric i
- 30 **C** Confirmed vs Book-3 §9.1 (PLF concept, Table 9.1) — Maximum possible generation = 2500 MW $\times 8760 \text{ h} = 21,900 \text{ GWh} = 21,900 \text{ million units}$; $\text{PLF} = 14,000/21,900 = 0.639 \approx 64\%$. Option (b) 79% would correspond to 17,300 MU; (a)
- 31 **A** % reduction in distribution loss = $[1 - (\text{PF}_{\text{old}}/\text{PF}_{\text{new}})^2] \times 100 = [1 - (0.8/0.95)^2] \times 100 = [1 - 0.709] \times 100 = 29.1\% \sim 29\%$.
The physics: for a fixed kW the line current is inversely proportional to PF, and loss goes a
- 32 **D** Forward-curved, backward-curved and radial are all CENTRIFUGAL impellers — air enters at the eye axially and is discharged radially, a 90° change of direction. Only the propeller fan (an axial machine) passes air straight
- 33 **A** Book-3 §10.2: after the EC (Amendment) Act 2010, ECBC applies to commercial buildings with connected load of 100 kW or more (or contract demand of 120 kVA or more). The exam question does not say 'minimum', but that is w
- 34 **B** Confirmed vs Book-3 §3.4 Compressed Air System Components (Figure 3.6) — Inter-stage coolers reduce the temperature of the air before it enters the next stage to reduce the work of compression and increase efficiency, by
- 35 **C** Confirmed vs Book-3 (ventilation rule) — Room volume = $15 \times 10 \times 4 = 600 \text{ m}^3$; at 20 air changes per hour the ventilation air required = $600 \times 20 = 12,000 \text{ m}^3/\text{hr}$. 30 (a) is the sum of

dimensions and 3000 (b) is a slip.

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- 36 **C** Confirmed vs Book-3 §6.5 — $Q \propto D$, so $D_2 = 230 \times (110/150) = 168.7 \approx 169$ mm. 207 mm would still deliver ~ 135 m³/hr; 175/195 mm do not match the ratio. The trim (to 73%) sits at the book's $\sim 75\%$ practical limit.
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- 37 **A** Confirmed vs Book-3 §10.5 — WWR = vertical fenestration area $\div$ gross exterior wall area (gross wall measured horizontally from the exterior surface and vertically from top of floor to bottom of roof). 'Net' wall area and
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- 38 **A** Confirmed vs Book-3 §3.5 Avoiding Air Leaks — % leakage = $T/(T+t) \times 100 = 10/(10+20) \times 100 = 33.3\%$, so leakage = $0.333 \times 200 = 66.7 \approx 67$ cfm.
The stem was missing the compressor capacity; the printed options fix it at 20
-
- 39 **D** Confirmed vs Book-3 §7.2 (vi)–(vii) — Blow Down = Evaporation/(COC – 1) and COC = TDS in circulating water / TDS in make-up water, so blowdown depends on all three quantities $\rightarrow$ (d).
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- 40 **C** Confirmed vs Book-3 §1.4 — capacitors 'act as reactive power generators', supplying the magnetising kVAr locally so it need not be drawn from the grid; the APFC keeps that compensation matched to a fluctuating load.
Opti
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- 41 **C** Confirmed vs Book-3 §6.2 — Book: 'The friction losses are proportional to the square of the flow rate.' This is why the system curve is parabolic and why halving flow cuts friction head to a quarter. Inverse relations (a
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- 42 **D** Confirmed vs Book-3 §6.3/§6.6 — For a centrifugal pump flow is zero at shut-off, head falls as flow rises, and efficiency peaks at the design (BEP) flow — a, b, c are all true. On throttling the duty point moves up the c
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- 43 **B** Confirmed vs Book-3 §6.5 — NPSHA = margin of eye pressure above vapour pressure; the book notes that as suction friction losses increase, NPSHA falls. A larger suction pipe lowers velocity and friction loss, so NPSHA inc
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- 44 **D** Confirmed vs Book-3 §2.8 Rewinding Effects on Energy Efficiency — The book names two indicators of rewind quality: the no-load current and the stator resistance per phase, both compared with the original values at the sa
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- 45 **A** Confirmed vs Book-3 §2.9 Soft Starter — The book's listed advantages of soft start are less mechanical stress, improved power factor, lower maximum demand and less mechanical maintenance. (b) and (c) state the exact oppo
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- 46 **D** Confirmed vs Book-3 §4.3 - Ammonia is used as the refrigerant in both vapour compression and vapour absorption (with water) systems. Lithium bromide (a) is the absorbent and water (b) the refrigerant only in LiBr machine
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- 47 **A** Confirmed vs Book-3 §3.5 Air Dryers (Tables 3.18 & 3.19) — Book-3: 'The most common adsorption materials used for compressed air drying are activated alumina and silica gel.'

Carbon and zirconium molecular sieves are not

- 48 **A** Confirmed vs Book-3 §2.7 Improving the Motor Loading by Operating in Star Mode — For motors consistently loaded below 40 % of rating, permanent star operation is the inexpensive fix — re-wiring the terminal box and reset
- 49 **B** Confirmed vs Book-3 §6.5 — $Q \propto D$, so $D_2/D_1 = Q_2/Q_1 = 100/120 = 0.833$; percentage reduction = $(1 - 0.833) \times 100 = 16.7\%$. 83.3% is the remaining diameter ratio, not the reduction; 33.3% would be the head reduction ($1 - 0.833^2$)
- 50 **B** Confirmed vs Book-3 §6.2 — The system curve is the head-loss vs flow relationship of the piping (a); friction $\propto Q^2$ makes it parabolic (c); with no static lift it starts at zero head and zero flow (d, Fig 6.5). It depends

S1 Compute AT&C (Aggregate Technical and Commercial) Losses for the given data: Input Energy $E_i=20$ MU, Energy Billed Metered $E_1=16$ MU, Un-metered $E_2=1$ MU, Total Billed $E_b=17$ MU, Amount Billed $A_b=Rs.800$ I...

S2 A multi storied office has centralized air conditioning system by using the chilled water. The chilled water inlet and outlet temperatures are 13°C and 9°C respectively. The chilled water pump dischar...

S3 List five energy saving measures in compressed air system....

S4 A process plant is situated 100 m up the side of the hill. The plant requires 100 kL of water per hour. The management decides to install a pump at the ground level, with suction 3 metre below the gro...

S5 Estimate the cooling tower capacity (TR) and approach: water flow $2 \text{ m}^3/\text{min}$, specific heat $1 \text{ kcal/kg}^\circ\text{C}$, inlet water 43°C , outlet water 35°C , ambient WBT 30°C

S6 Find out the Effective Aperture (EA) of the following two glazing and comment about compliance with ECBC. Case #1: Window to Wall Ratio (WWR) 0.2, Visible Light Transmittance (VLT) Transparent (perfec...

- S7** A V-belt driven centrifugal fan is supplying air to a chemical process. Calculate the fan static efficiency for the following operating parameters: Ambient temperature 40degC; Density of air 1.127 kg/...
- S8** A 5 MW DG set running at 70% load for base load operation generates 8.6 kg of exhaust gas per kWh. The exhaust gas is reduced to 200oC. The specific heat of flue gas is 0.26 kcal/kg-oC. The steam gene...
- L1** A review of electricity bills of a process plant was conducted as a part of energy audit. The plant has a contract demand of 3000 kVA with the power supply company. The average maximum demand of the p...
- L2** a) Calculate the filter area of an Air Handling Unit (AHU) for Refrigeration Load of 50 TR. The air enthalpy at inlet of AHU is 85 kJ/kg and at outlet is of 60 kJ/kg. Air velocity at filter is 1.81 m/...
- L3** In a steel industry, cooling water of 7500 m³/hr and 4200 m³/hr from two different sections with temperatures of 38 °C and 55 °C respectively, are fed to cooling tower after proper mixing. If the meas...
- L4** Rated capacity of a fresh water shut-discharge pump flow rate is 485 m³/hr and discharge pressure is 13.5 kg/cm² at rated speed of 2950 rpm. It has been observed that 450 m³/hr water is sufficient to ...
- L5** L-6: An engineering industry operating three shifts per day has replaced its old reciprocating compressors with 1000 CFM screw compressors. During the energy audit, run hours counter readings: Load Ho...

L6 L3 a) Match the following: (4 Marks)

1 Prescriptive Approach

2 Whole Building Performance Approach

3 Building envelope

4 Effective Aperture

Options:

1. Exterior façade

2. Trade-Off option

3. light adm...