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AEE CEM

Version Demo

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QUESTION NO: 1

A variable-air-volume supply fan draws 60 kW at full design speed. During most occupied hours, the required airflow can be met at 80% of design speed. Assuming the fan follows the affinity laws and variable-speed-drive losses are negligible, what is the expected fan input power at this condition?

A. 24 kW

B. 31 kW

C. 38 kW

D. 48 kW

E. 60 kW

ANSWER: B

Explanation:

31 kW is correct. For a centrifugal fan operating along a similar system curve, power varies approximately with the cube of rotational speed. Therefore, the part-load input is 60 kW × $(0.80)^3$ = 30.72 kW, or approximately 31 kW. The 48 kW result would incorrectly assume that power changes directly with speed. The large reduction from only a 20% speed decrease is the principal energy-saving benefit of variable-speed control for centrifugal fans.

QUESTION NO: 2

Which type of lighting control technique operates in "manual on" and "auto-off mode, and can be used in situations where there is brief occupancy that do not need lights on?

A. Microphonics technology

B. PIR/Microphonics dual technology

C. Photocell control

D. Vacancy sensor

E. Occupancy sensor

ANSWER: D

Explanation:

Vacancy sensor is correct because its intended control sequence is manual-on with automatic-off. A person must deliberately switch the lights on when illumination is needed; the sensor then detects that the space has become vacant and turns the lights off after the selected time delay. This approach avoids energizing lighting merely because someone passes briefly through, enters to retrieve an item, or otherwise occupies the area without needing task illumination. It therefore provides an effective energy-saving strategy where automatic activation would create unnecessary lighting run time while still ensuring that lights do not remain on after the space is empty.

The U.S. Department of Energy describes occupancy-sensing controls as devices that use sensors to switch lighting based on presence and notes their role in reducing energy use in intermittently occupied spaces. Vacancy sensing applies the same automatic shutoff principle while requiring the occupant's affirmative manual action to turn lighting on. This manual-on/automatic-off operation is also recognized in commercial energy-code control provisions as a distinct lighting-control function. See the U.S. Department of Energy's Lighting Controls guidance and the California Energy Commission's Building Energy Efficiency Standards resources.

QUESTION NO: 3

Lighting systems operate with a certain recoverable light loss factor. Control systems with photocell sensor inputs combined with dimming ballasts can be used to regulate dimming levels to maintain a continuous light level in the work space. Which of the following best describes this type of control?

A. Closed-loop controller

B. Open-loop controller

C. Demand-limiting controller

D. Two-position controller

ANSWER: A

Explanation:

Closed-loop controller is correct because the photocell measures the illumination that actually reaches the controlled work area and feeds that measured value back to the lighting controller. The controller continuously uses this feedback to adjust the dimming ballast output, increasing electric-light output when measured illuminance falls below the desired level and reducing it when daylight or other available light raises the measured level. This feedback process enables the system to maintain a target, relatively continuous illuminance despite variations in daylight, lamp lumen depreciation, dirt accumulation, and other light-loss conditions. In lighting applications, this approach is commonly associated with daylight harvesting when the sensor is positioned to respond to the light level in the space being controlled. The U.S. Department of Energy describes photosensors as controls that adjust electric lighting in response to available daylight, while lighting-control guidance distinguishes closed-loop daylight-responsive control by its use of measured light in the controlled area. See the U.S. Department of Energy's overview of lighting controls and the DesignLights Consortium's daylight harvesting guide.

QUESTION NO: 4

In a PID control system, what is the purpose of the Proportional Gain?

A. Reacts to the current control error

B. Reduces/eliminates offset

C. Senses high load rate

D. Control point

ANSWER: A

Explanation:

Proportional gain reacts to the current control error: the difference between the measured process variable and its setpoint. Its output contribution is calculated as the proportional-gain setting multiplied by that instantaneous error. Consequently, when the error becomes larger, proportional action calls for a correspondingly larger corrective output; as the process approaches setpoint, that contribution decreases. In energy systems, such as temperature, pressure, flow, or combustion controls, proportional gain therefore establishes how strongly and promptly the controller responds to a present departure from the desired operating condition. Appropriate tuning provides meaningful corrective action without causing excessive cycling or instability. This behavior is the defining relationship for the proportional term in the standard PID equation, commonly expressed as $P = Kp \times e(t)$, where Kp is proportional gain and e(t) is the current error. The U.S. National Institute of Standards and Technology describes PID controllers as using proportional action based on the present error, with integral and derivative actions adding their respective time-based functions. See NIST's PID controller overview and PID controller reference material.

QUESTION NO: 5

When comparing two similar facilities, you see that the facility with newer, higher-efficiency equipment has a higher energy-use index [EUI] (kJ/m²-yr). What might be the cause?

A. The facility with the higher EUI is in need of commissioning

B. The facility with the lower EUI is in need of commissioning

C. The facility with the lower EUI requires a performance contract

D. The facility with the higher efficiency equipment should have a higher EUI

E. The facility with the higher EUI requires a supervisory control and data acquisition (SCADA) system

ANSWER: A

Explanation:

The facility with the higher EUI is in need of commissioning is correct because installed equipment efficiency alone does not ensure low whole-building energy use. Commissioning verifies, through systematic testing and documentation, that building systems are installed, controlled, and operated according to the owner's requirements and design intent. A newer high-efficiency chiller, boiler, air-handling system, or lighting-control system can consume substantially more energy than expected if schedules are excessive, control sequences are incomplete, sensors or actuators are improperly calibrated, simultaneous heating and cooling occurs, equipment fails to reset at part load, or systems are overridden after installation.

EUI is a whole-facility metric, so it captures the operational outcome of equipment, controls, occupancy patterns, and maintenance rather than merely the nameplate efficiency of individual assets. When otherwise comparable facilities show the counterintuitive result that the newer facility has a higher EUI, commissioning is an appropriate potential cause to investigate because it identifies and corrects deficiencies in integration, sequencing, and functional performance. The U.S. Department of Energy describes commissioning as a quality-focused process for ensuring that systems perform according to project requirements. See U.S. Department of Energy: Commissioning and ENERGY STAR: Benchmarking.

QUESTION NO: 6

A heat pump water heater has an annual average coefficient of performance (COP) of 2.1 and heats water from 15°C to 50°C. Hot water use is 100 liters per day, 365 days/yr. The electricity cost is $0.10/kWh. What is the annual water heating cost? (The specific heat of water (C) is 4.2 kJ/kg-°C.)

A. $44.88/year

B. $52.20/year

C. $64.66/year

D. $70.97/year

E. $88.29/year

ANSWER: D

Explanation:

$70.97/year is correct. The required temperature rise is 35°C, calculated as 50°C minus 15°C. Since one liter of water has a mass of approximately one kilogram, the daily water mass is 100 kg. The daily heat delivered to the water is therefore 100 kg × 4.2 kJ/kg-°C × 35°C = 14,700 kJ/day. Converting this thermal energy to kilowatt-hours gives 14,700 ÷ 3,600 = 4.083 kWh/day of heat delivered. Over 365 days, the annual water-heating load is 1,490.4 kWh of thermal energy. COP is the ratio of useful heat delivered to electrical energy consumed, so the heat pump's annual electrical input is 1,490.4 ÷ 2.1 = 709.7 kWh/year. At an electricity price of $0.10 per kWh, annual operating cost is 709.7 × $0.10 = $70.97/year. This treatment is consistent with the definition of COP used for heat-pump water heaters: useful heat output divided by electrical energy input. The U.S. Department of Energy describes heat-pump water heaters as moving heat rather than generating it directly, which enables efficiency above that of resistance heating. See U.S. DOE: Heat Pump Water Heaters and U.S. DOE: Water Heating.

QUESTION NO: 7

What is the uniform series present worth factor (P/A, i%, n) for an annual interest rate of 15% and a lifetime of 20 years?

A. 0.160

B. 0.214

C. 4.676

D. 6.259

ANSWER: D

Explanation:

The correct uniform-series present-worth factor is **6.259**. The present-worth factor converts a level annual end-of-year amount into its equivalent value at time zero, using the stated annual discount rate and number of annual periods. For a uniform annual series, the factor is calculated as $P/A = [1 - (1 + i)^{-n}] / i$. Substituting an annual interest rate of 0.15 and a lifetime of 20 years gives $[1 - (1.15)^{-20}] / 0.15$. The reciprocal discount term is approximately 0.0611, so the result is approximately (1 − 0.0611) / 0.15 = 6.259. Thus, one unit of recurring annual cash flow over 20 years has a present value of about 6.259 units when discounted at 15% annually. This is the standard engineering-economy annuity present-worth relationship used in life-cycle cost and energy-project evaluations, provided that the payments occur at the end of each year and the discount rate is applied consistently on an annual basis. See the uniform-series present-worth discussion at Engineering ToolBox and the present-value annuity formula at Investopedia.

QUESTION NO: 8

A motor operates with a normal and constant load. The electric current is measured to be 25% of the motor's nameplate rating. What does this mean?

A. The motor is operating at high efficiency

B. The motor is oversized and may be downsized to increase efficiency

C. The applied voltage is too low and should be increased to improve efficiency

D. The applied voltage is too high and should be reduced to improve efficiency

ANSWER: B

Explanation:

The motor is oversized and may be downsized to increase efficiency. For a motor driving a stable, normal load, current at only 25% of nameplate full-load current is a strong field indication that the motor has substantially more capacity than the driven equipment requires. Induction motors consume magnetizing current even at light load, and their power factor and efficiency typically decline as loading falls far below the range for which they were designed. Consequently, a correctly selected smaller motor can operate nearer its efficient loading range, reducing electrical losses and often improving power factor as well. In an energy assessment, measured current is an initial screening measurement; the final replacement decision should also verify real input power, actual shaft-load requirement, operating hours, service factor, starting/acceleration needs, load variability, and the appropriateness of the motor’s speed and enclosure. The U.S. Department of Energy identifies proper motor sizing as an important motor-system efficiency practice and notes that oversized motors can operate inefficiently at light loads. See the DOE’s Motor Systems resources and the ENERGY STAR Electric Motors guidance.

QUESTION NO: 9

If outside air has a temperature of 25°C dry bulb and 15°C wet bulb, what is the enthalpy of the air?

A. 32 kJ/kg

B. 42 kJ/kg

C. 52 kJ/kg

D. 62 kJ/kg

ANSWER: B

Explanation:

42 kJ/kg is the appropriate enthalpy at the stated condition, expressed per kilogram of dry air. Using a standard sea-level psychrometric chart, locate the 25°C dry-bulb temperature on the horizontal axis and follow the 15°C wet-bulb-temperature line to its intersection. Reading across the enthalpy scale gives approximately 41–42 kJ/kg of dry air, so 42 kJ/kg is the best available answer.

The same result can be verified from psychrometric relations. At 15°C wet bulb and standard atmospheric pressure, the air has an approximate humidity ratio of 0.0064 kg water vapor per kg dry air. Applying the moist-air enthalpy relation, $h = 1.006T_{db} + W(2501 + 1.86T_{db})$, with $T_{db} = 25°C$, produces an enthalpy close to 41.4 kJ/kg dry air. The small difference between this calculated value and 42 kJ/kg reflects chart-reading precision and normal rounding in multiple-choice practice. ASHRAE identifies psychrometrics as the basis for determining moist-air properties and provides relevant resources through its ASHRAE Handbook. A practical overview of the enthalpy relationship is also available from The Engineering ToolBox.

QUESTION NO: 10

A water-cooled chiller has experienced a sustained increase in kW/ton. Chilled-water supply temperature, chilled-water flow, compressor loading, and entering-air wet-bulb temperature are unchanged from baseline. Condenser-water flow is also unchanged, but the condenser-water temperature leaving the cooling tower is 3°C higher than baseline while tower fans operate at full speed. Which condition is the most likely cause?

A. Reduced chilled-water flow through the evaporator

B. Reduced building cooling load

C. Excessive chilled-water supply-temperature setpoint

D. Fouled or obstructed cooling-tower fill

E. Increased refrigerant charge in the chiller

ANSWER: D

Explanation:

Fouled or obstructed cooling-tower fill is correct. With similar entering-air wet-bulb temperature and condenser-water flow, a higher tower leaving-water temperature indicates degraded heat rejection by the cooling tower. Fouled fill, scale, biological growth, or airflow blockage can increase tower approach temperature and raise chiller condensing pressure, causing kW/ton to increase. A chilled-water flow problem is inconsistent with the stated unchanged chilled-water flow and supply temperature. A lower evaporator load would normally reduce compressor loading rather than explain the elevated condenser-water temperature. Refrigerant undercharge can affect chiller performance, but it does not directly explain the degraded cooling-tower approach under the stated conditions.

QUESTION NO: 11

The temperature in an unconditioned mechanical room is found to typically be around 23°C warmer than ambient air. If the air intake of an air compressor located in the mechanical room is routed through a nearby wall so that ambient air is fed directly to the air compressor's intake, what impact can be expected on the air compressor's energy requirement?

A. Increase energy use by 7.6%

B. Increase energy use by 3.8%

C. No measureable change in energy use

D. Decrease energy use by 3.8%

E. Decrease energy use by 7.6%

ANSWER: E

Explanation:

Decrease energy use by 7.6% is correct. Cooler inlet air is denser, so the compressor draws in a greater mass of air for a given inlet volume and requires less compression work to deliver its rated compressed-air output. A commonly used compressed-air energy-management rule of thumb is that compressor energy consumption decreases by approximately 1% for each 3°C reduction in inlet-air temperature. Routing the intake from the mechanical room to outdoors reduces inlet temperature by approximately 23°C. Applying the rule gives 23°C ÷ 3°C per percent = 7.67%, which rounds to a 7.6% reduction in energy requirement. This improvement occurs at the compressor inlet and does not require changing the compressor's pressure setpoint, controls, or air-demand profile. In practice, the outside-air intake should be located and filtered to prevent rain, contaminants, exhaust gases, or recirculated hot discharge air from entering the compressor. The U.S. Department of Energy identifies inlet-air temperature as an important factor in compressed-air system performance and recommends using the coolest practical, clean source of intake air. See the U.S. Department of Energy compressed-air systems resources and the Compressed Air Challenge sourcebook library.

QUESTION NO: 12

A 75-kW induction motor operates at 80% partial load and 88% efficiency. A new high-efficiency 75-kW motor can be installed that will operate at 95% efficiency (also at 80% partial load). What is the reduction in electric power demand?

A. 1 kW

B. 2 kW

C. 4 kW

D. 5 kW

E. 8 kW

ANSWER: D

Explanation:

The correct answer is **5 kW**. The 75 kW motor rating represents rated shaft output, not the electrical input demand. At 80% load, the driven equipment requires shaft output of 75 kW × 0.80 = 60 kW. Electrical input power is determined by dividing this shaft output by motor efficiency. Thus, the existing motor draws 60/0.88 = 68.18 kW, while the replacement high-efficiency motor draws 60/0.95 = 63.16 kW at the same load. The demand reduction is therefore 68.18 − 63.16 = 5.02 kW, which rounds to 5 kW. This calculation appropriately holds mechanical output constant because the replacement motor serves the same load at the same partial-load operating point. Motor efficiency is the ratio of mechanical output power to electrical input power, so improving efficiency reduces electrical demand even though the required shaft power remains unchanged. The U.S. Department of Energy identifies energy-efficient motors as a means of reducing motor-system electricity use; see its motor systems resources. The relationship between input, output, and efficiency is also consistent with NEMA motor technical resources: NEMA Motors and Generators standards.

QUESTION NO: 13

If the temperature difference across an external wall is 20°C and the heat flow across the wall is 2.5 Watts/m², calculate the insulation value of the wall (including inside and outside air films)?

A. R = 4 m²-°C/W

B. R = 6 m²-°C/W

C. R = 8 m²-°C/W

D. R = 10 m²-°C/W

E. R = 12 m²-°C/W

ANSWER: C

Explanation:

R = 8 m²-°C/W is correct because the overall thermal resistance of the wall assembly is calculated by dividing the temperature difference across the assembly by the steady heat flux through it: $R = \Delta T/q$. Here, the temperature difference is 20°C and the heat flow rate per unit area is 2.5 W/m². Thus, $R = 20/2.5 = 8$ m²·°C/W. Temperature differences expressed in degrees Celsius and kelvins have the same numerical magnitude, so the equivalent SI unit can also be written as m²·K/W. Because the question specifies that inside and outside air films are included, this result represents the total or overall thermal resistance from indoor air to outdoor air, rather than the resistance of wall materials alone. This relationship is the area-normalized form of one-dimensional steady-state heat transfer, where heat flux equals the temperature difference divided by total thermal resistance. See the [Engineering ToolBox overview of thermal resistance and heat transfer]() and the [U.S. Department of Energy guidance on insulation and R-values]().

QUESTION NO: 14

A new lighting system costs $60,000. The new lighting system has a 15-year life and the minimum required rate of return (MARR) is 15%. How much must the new lighting system save to be life-cycle cost effective?

A. $10,260/year

B. $12,556/year

C. $15,650/year

D. $27,090/year

E. $33,200/year

ANSWER: A

Explanation:

$10,260/year is the required annual savings because the $60,000 first cost must be converted to an equivalent uniform annual cost over the lighting system's 15-year service life at the 15% MARR. For a project with no stated salvage value, annual operating-cost differences, or escalation, the break-even annual savings equal the initial investment multiplied by the capital-recovery factor: $CRF = i(1 + i)^n/[(1 + i)^n - 1]$. Using $i = 0.15$ and $n = 15$ gives a capital-recovery factor of approximately 0.1710. Therefore, the annual savings required are $60,000 × 0.1710 = approximately $10,261 per year, which rounds to $10,260/year. At this savings level, the present value of the annual savings stream exactly recovers the initial cost at the specified MARR, yielding a net present value of zero. Savings above this amount produce a positive net present value and satisfy the required return. This equivalent-annual-cost method is a standard life-cycle-cost technique for evaluating alternatives with a known first cost, life, and discount rate. See the U.S. Department of Energy's [Life-Cycle Cost Analysis]() guidance and NIST's [Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis]().

QUESTION NO: 15

Which pump system listed below is most likely the best application for converting to variable-speed drive?

A. Pump system with parallel rotary lobe pumps in a rebar quenching application with a static head of 80m

B. Pump system with on-off control transferring liquid vertically from a low tank to a higher tank

C. Pump system with bypass control transferring liquid from an intake dam to a process in production

D. Pump system with throttle fully open circulating liquid in a closed loop cooling system

ANSWER: C

Explanation:

Pump system with bypass control transferring liquid from an intake dam to a process in production is the best candidate for conversion to variable-speed drive control. Bypass control maintains a required process flow by pumping more liquid than is needed and routing the surplus back through a recirculation path. Although this provides controllability, the pump continues to consume energy to produce flow that does not serve the process. A variable-speed drive can instead reduce pump speed as process demand falls, allowing the pump to produce closer to the required flow while avoiding the energy waste associated with bypassing excess liquid.

This is especially beneficial where production flow demand varies over time, as is commonly the case for process supply systems. For a centrifugal pump, the affinity laws show that flow changes approximately in proportion to speed and power changes approximately with the cube of speed. Consequently, even a modest speed reduction can yield substantial electrical-energy savings when system requirements permit it. The U.S. Department of Energy identifies adjustable-speed pumping as an important efficiency measure for variable-flow systems, particularly where throttling or bypass control is used. See the U.S. Department of Energy Pumping Systems resources and the Improving Pumping System Performance Sourcebook.

QUESTION NO: 16

An air-conditioning unit delivers 10,000 kJ/h (thermal cooling). The equipment uses single-phase electrical power at 220-volt and 5.25 amps with a power factor of 100%. Calculate the coefficient of performance (COP).

A. 2.4

B. 3.2

C. 6.2

D. 13.2

E. 16.1

ANSWER: A

Explanation:

2.4 is correct because the cooling COP is the ratio of useful cooling output to electrical power input, with both quantities expressed in consistent energy-rate units. For a single-phase load, real electrical input power equals voltage multiplied by current multiplied by power factor. With a 100% power factor, the unit's input is 220 V × 5.25 A = 1,155 W, or 1.155 kW. Since 1 kW is equivalent to 3,600 kJ/h, this input is 1.155 × 3,600 = 4,158 kJ/h. The cooling capacity is 10,000 kJ/h, so COP = 10,000 ÷ 4,158 = 2.405, which rounds to 2.4. COP is dimensionless because it compares two rates of energy transfer. This calculation uses electrical real power rather than apparent power; here they are numerically equal because the stated power factor is unity. The result means the air-conditioning equipment provides approximately 2.4 units of cooling energy for every unit of electrical energy consumed. The U.S. Department of Energy describes air-conditioner efficiency in terms of cooling delivered relative to energy input, while NIST provides the SI relationship between watts and joules used for the unit conversion. See U.S. Department of Energy: Central Air Conditioning and NIST: SI Units.