46.5 A group of machines are maintained under a contract which costs \$50,000 this year. The contract cost will inrease by \$1000 per year over the next 10 years. What is the present value of the entire 10 years of maintenance using an effctive annual interest rate of 12%.

A. \$303,000

B. \$336,000

C. \$352,000

D. \$370,000

The present value can be represented as the sum of two cash flows: a recurring annual cost of \$50,000 and a uniform gradient of \$1,000. The gradient has a value of zero in the first year, such that the first year cost is \$50,000, second year is \$51,000, third year is \$52,000, etc. There is no initial cost reflected in year 0 as it is customary in engineering economics to reflect costs that occur throughout the year at the end of the year.

Write an expression for the present value.

$$PV = A\,(P/A, 12\%, 10) + G\,(P/G, 12\%, 10)$$

Use the 12% Factor Table to look up the cash flow factors needed to translate the cash flows into present value. Solve for the present value.

$$PV = (\$50,000)\,(5.6502) + (\$1,000)\,(20.2541) = \$302,764$$

Answer A

46.6 A pump delivers 200 GPM of water at 130 feet of total dynamic head, operating from 7am-7pm Monday through Friday. The pump is 80% efficient and the motor is 93% efficient. What is the annual cost of operation at \$0.13 per kWh?

A. \$2670

B. \$3490

C. \$3750

D. \$5030

The cost is a function of electrical power and time, and electrical power is a function of hydraulic horsepower (aka water horsepower i.e. whp) and efficiency. Start by calculating the water horsepower based on volume flow rate and feet of head provided by the pump:

$$whp = \frac{Q\Delta h}{3960} = \frac{(200)\,(130)}{3960} = 6.566hp$$

Note the volume and head units must be in GPM and ft, respectively, to use this "rule of thumb" equation. Therefore units need not be shown, provided they are confirmed to be correct prior to use.

Recall that brake horsepower, bhp, depends on water horsepower, whp, and the efficiency of the pump, η_p. Similarly, the electrical power, $\dot{W}$,depends on brake horsepower, bhp, and motor efficiency, η_m.

$$bhp = \frac{whp}{\eta_p}$$

$$\dot{W} = \frac{bhp}{\eta_m}$$

Put these together, substitute, solve, and convert to KW:

$$\dot{W} = \frac{whp}{\eta_p \eta_m} = \frac{6.566hp}{(.8)\,(.93)}\left(\frac{.746KW}{1hp}\right) = 6.58KW$$

To find the annual cost, multiply by time and the unit rate of electricity:

$$Cost = (6.58KW)\left(\frac{12hrs}{day}\right)\left(\frac{5days}{wk}\right)\left(\frac{52wks}{yr}\right)\left(\frac{\$0.13}{KWH}\right) = \$2669\,per\,year$$

Answer A

46.7 A $7.5hp$ single phase $230V$ motor drawing $40A$ at full load is located $50\,meters$ from the voltage source. The motor is wired with $8AWG$ wire which has a cross sectional area of $16,509\,circular\,mils$ ($1\,circular\,mil = 5.066 \times 10^{-10}m^2$) and a resistivity of $1.724 \times 10^{-8}\Omega \cdot m$. What is the percent voltage drop for the wiring in the circuit?

A. 1%

B. 2%

C. 3%

D. 4%

The electrical resistance attributable to the wiring is the result of copper's resistivity, which is an intrinsic material property, and the length and gauge of the wire. The formula for resistivity can be rearranged to solve for the total resistance.

$$\rho = \frac{RA}{L}$$

$$R = \frac{\rho L}{A}$$

Since the motor is $50ft$ from the voltage source, a sufficient length of wire must be provided to make a round trip from the source to the load and back. Therefore, the total length is given by: