

Use estimates to problem solve

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities

Program Task: Gather and use information in the workplace.

Program Associated Vocabulary:

ESTIMATE, ASSESS, PREDICT, DIAGNOSE

Program Formulas and Procedures:

HVAC professionals routinely compare *estimated* values while diagnosing equipment. The technician lists observations and performs tests (uses tools and skills) to determine values sets that describe the current status of a system or component. Then the HVAC technician compares the derived value with a known *average* value that is considered as appropriate to a relatively normal condition. A significant discrepancy between the two values indicates a fault.

Once a system fault is identified, HVAC technicians estimate corrective action costs by rounding material prices and averaging labor hours required.

DIAGNOSTIC PROCESS = SKILLED ESTIMATING

1. Collect list of symptoms using all available input (customer's input, technician's observations, etc.).
2. Determine diagnostic start point.
3. Perform appropriate tests.

T / F: Observations = Estimation of Normal Values

4. If EQUATION above is FALSE, problem exists.
5. If EQUATION above is TRUE, problem is elsewhere or non-existent.

Example: Is there a real problem with the fuel pressure of a given oil burner, if the current psi is 85 and the estimated appropriate psi is 100?

Solution:

$$\frac{\text{Current fuel pressure} = \text{Value of appropriate fuel pressure}}{85\text{psi} \neq 100\text{psi}}$$

Logic: Equation is False because the current value of 85 psi is not equal to the expected value of 100 psi.

Conclusion: A problem exists.

PA Core Standard: CC.2.1.HS.F.5

Description: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Math Associated Vocabulary:

ROUNDING, PLACE VALUE, MENTAL MATH, AVERAGE

Formulas and Procedures:

It is often more practical to use estimation to solve problems, using mental math, so that a calculator is not necessary. Usually the situations presented require you to either round to the nearest whole number, tens, hundreds, or thousands, or require you to take an average of the range of numbers given. The two examples below demonstrate specific situations where rounding and averaging are useful.

Rounding:

Henry just purchased a cell phone plan that will cost him \$38.99 per month. His friend, Elizabeth, just purchased a cell phone plan that will cost her \$59.99 per month. Estimate how much more money Elizabeth will spend on her cell phone plan in one year.

1. To estimate, round to the nearest tens. Henry will spend about \$40/mo. and Elizabeth will spend \$60/mo.
2. Take the difference between the two: $\$60 - \$40 = \$20$ to determine how much more Elizabeth will spend in one month.
3. Multiply by 12. $\$20 \times 12 = \240 more per year.

Averaging:

Billy notices that 4-6 cars pass by his house each hour. Estimate the number of cars that will pass by his house in 8 hours.

1. Find the average of 4 and 6. $\text{Average} = (4 + 6) \div 2 = 5$.
2. Multiply this by 8 hours: $5 \times 8 = 40$
Approximately 40 cars should pass by his house.

Instructor's Script - Comparing and Contrasting

On the surface it may appear that estimating and diagnostics are unrelated. However, consider the first T-Chart math example from a slightly different perspective. If you are Elizabeth, you are paying \$60 per month for your phone and you have just observed that your friend Henry is paying only \$40 per month for his phone. You not only rounded off the billing numbers, you may have also done some quick division and determined that you are paying 50% more than Henry is paying, which most people would consider to be a significant difference. *You've just demonstrated estimating as a diagnostic tool.*

You may be justified in concluding that a problem exists, but you would need to confirm with further testing (e.g., are the plans similar in benefits?). Or you may poll more friends and take an average of their monthly bills to make your decision. From the information given though, it appears that Elizabeth should take some corrective action.

If the benefits were similar and the cost difference was only \$5 instead of \$20, Elizabeth may conclude that no significant problem exists. Somewhere in her thought process is an estimated boundary line for the given situation

Troubleshooting any problem involves logic and a scientific process, but it also involves the fine art of skilled estimating.

Skilled estimating is a function of efficiency and productivity. It is counterproductive to spend excessive amounts of time calculating detailed numbers when estimates will suffice. There are times when estimates are not appropriate, and detailed accuracy is needed.

The HVAC professional must be able to describe systems and machines almost exclusively in terms of numeric values. A higher level of estimating skills is typically indicative of technical proficiency.

Proficient diagnosticians summon data from past experiences and average results to provide educated responses to diverse challenges. They are skillful estimators who study the past to determine what is happening now, what will happen next, and what can be done to repair or enhance system performance.

Common Mistakes Made By Students

Problems arise when the students do not consider the limitations of estimating and how the situation determines when to estimate. For instance, it is not okay to round up 85 psi to 100 psi. However, if a faulty component will cost the customer \$85, it would be okay to round it to \$100 when estimating the cost.

CTE Instructor's Extended Discussion

This unit on estimating provides an excellent opportunity to discuss with the class, the nature of diagnosing suspected equipment and system problems. We don't always think of troubleshooting and estimating in the same sentence, however, an argument can be made that they are very closely related. Consider how most diagnoses begin with a question, a mathematical equation (which includes an estimate), a logic question, and an IF/THEN statement.

Role of Estimating (i.e. example on page 1): Estimating plays an important, integral role in routine decision making processes, like troubleshooting. In the example on page 1, the 100 psi is a standard estimate. If the observed oil pressure had been 99 psi or 101 psi, most technicians would have rounded it to 100. If it had been 104, most would consider it a high average but would not deem the pressure difference to be significant. Only the most meticulous technician would adjust pump pressure from 101 to 100 psi. Even then, the technician would have to consider if his or her pressure gauge was truly that accurate. In the end, even a gauge reading of 100 psi should be considered approximate at best.

HVAC (47.0201) T-Chart

| Problems | Occupational (Contextual) Math Concepts | Solutions |
|--|---|-----------|
| 1. You perform a heat load calculation and determine that a structure requires 55,000 BTUs/hr. of cooling. Round that up to the nearest "ton" of cooling. Remember that a cooling ton is 12,000 BTU/hr. | | |
| 2. You have 3 oil burner nozzles options. Nozzle A GPH rate is 0.65; Nozzle B is 0.75, and Nozzle C is 0.85. You do a heat loss calculation and determine that the building loses 107,000 BTU/hr. on a designated winter day. Given that the fuel oil contains about 140,000 BTUs/Gal., which nozzle is closest to the heat loss calculation? Remember that over sizing the nozzle tends to decrease overall efficiency of the system. | | |
| 3. Based on HVAC trade estimations, you know that a certain building requires about 1 ton of cooling for every 400 square feet of floor space. In one open office area, you count 2' x 4' ceiling tiles and determine that there are 100 tiles in the room. About how many tons of cooling should be dedicated to that space? | | |
| Problems | Related, Generic Math Concepts | Solutions |
| 4. A software support contract is quoted for one or two years. One year would cost \$795 but two years would cost \$1495. Round each price to the nearest hundred dollars to estimate the savings for a two year commitment. | | |
| 5. Students want to raise \$500 for a field trip. With fundraising, they collected \$127 on Monday, \$130 on Tuesday, \$84 on Wednesday, and \$90 on Thursday. Approximately how much money will they need to collect on Friday to reach their goal? | | |
| 6. A car can be rented for \$37.99/day plus \$0.39/mile. Which of the following is the best estimate for the cost of renting the car for 4 days if you are driving 100 miles? a) \$150 b) \$160 c) \$200 d) \$250 | | |
| Problems | PA Core Math Look | Solutions |
| 7. A company is offering a salary of \$48,500 per year. If about 20% is taken from taxes, how much will a person have made in 5 years after taxes? | | |
| 8. Every hour, the store sells between 40-50 items that range from \$1.99 - \$7.99. What would be a good estimate for the amount of money the store generates in a 10 hour day? | | |
| 9. Two friends went to dinner. Their bill came to \$37.79. If a fair tip is between 15 and 20 percent, what would be a fair tip to leave their waiter? | | |

| Problems | Occupational (Contextual) Math Concepts | Solutions |
|--|--|---|
| 1. You perform a heat load calculation and determine that a structure requires 55,000 BTUs/hr. of cooling. Round that up to the nearest "ton" of cooling. Remember that a cooling ton is 12,000 BTU/hr. | | $55,000/12,000 = 4.5833$ tons rounded to 5 tons. You should choose the 5 ton unit. |
| 2. You have 3 oil burner nozzles options. Nozzle A GPH rate is 0.65; Nozzle B is 0.75, and Nozzle C is 0.85. You do a heat loss calculation and determine that the building loses 107,000 BTU/hr. on a designated winter day. Given that the fuel oil contains about 140,000 BTUs/Gal., which nozzle is closest to the heat loss calculation? Remember that over sizing the nozzle tends to decrease overall efficiency of the system. | | $0.65 \times 140,000 \text{ BTUs} = 91,000 \text{ BTUs}$ $0.75 \times 140,000 \text{ BTUs} = 105,000 \text{ BTUs}$ $0.85 \times 140,000 \text{ BTUs} = 119,000 \text{ BTUs}$ You should choose the 0.75 GPH nozzle, even though it is slightly under your heat loss estimate (107,000BTU/hr). |
| 3. Based on HVAC trade estimations, you know that a certain building requires about 1 ton of cooling for every 400 square feet of floor space. In one open office area, you count 2' x 4' ceiling tiles and determine that there are 98.5 tiles in the room. About how many tons of cooling should be dedicated to that space? | | Each 2 x 4 ceiling tiles is 8 square feet. 98.5 tiles would mean the space is about $8 \times 100 = 800$ square feet. $800/400 = 2$ tons of cooling. |
| Problems | Related, Generic Math Concepts | Solutions |
| 4. A software support contract is quoted for one or two years. One year would cost \$795 but two years would cost \$1495. Round each price to the nearest hundred dollars to estimate the savings for a two year commitment. | | Rounding off, one year = \$800, while two years = \$1,500. $\$1,500 / 2 = \750 per year, or a \$50 per year savings for the two year commitment, or \$100 savings for the two years. |
| 5. Students want to raise \$500 for a field trip. With fundraising, they collected \$127 on Monday, \$130 on Tuesday, \$84 on Wednesday, and \$90 on Thursday. Approximately how much money will they need to collect on Friday to reach their goal? | | Rounding the amounts to the nearest ten, $130 + 130 + 80 + 90 = 430$ 500 (their goal) – 430 (the approx. amt. collected) = \$70 is approximate amount they would need to collect on Friday |
| 6. A car can be rented for \$37.99/day plus \$0.39/mile. Which of the following is the best estimate for the cost of renting the car for 4 days if you are driving 100 miles? a) \$150 b) \$160 c) \$200 d) \$250 | | c) \$200 C = Total Cost x = # of days y = # of miles Equation: $C = 37.99(x) + .39(y)$ Estimate Amounts: $C = 40x + .40x$ Substitute and Solve: $C = 40(4) + .40(100)$ $C = 160 + 40 = \$ 200$ |
| Problems | PA Core Math Look | Solutions |
| 7. A company is offering a salary of \$48,500 per year. If about 20% is taken from taxes, how much will a person have made in 5 years after taxes? | | \$50,000 salary estimate. 10% is \$5,000, so 20% is \$10,000. $5 \text{ years} \times \$10,000 \text{ tax/year} = \$50,000 \text{ taxes in } 5 \text{ years.}$ $\$50,000 \text{ salary} \times 5 \text{ years} = \$250,000 \text{ estimated salary for } 5 \text{ years}$ $\$250,000 \text{ (estimated salary)} - 50,000 \text{ (estimated taxes)} =$ $\$200,000 \text{ (estimated net, or after tax income for } 5 \text{ years)}$ |
| 8. Every hour, the store sells between 40-50 items that range from \$1.99 - \$7.99. What would be a good estimate for the amount of money the store generates in a 10 hour day? | | $45 \times \$5 = \225 per hour $\$225 \text{ per hour} \times 10 \text{ hour day} = \2250 per day |
| 9. Two friends went to dinner. Their bill came to \$37.79. If a fair tip is between 15 and 20 percent, what would be a fair tip to leave their waiter? | | Estimate a \$40 bill. 10% is \$4. 20% is \$8, so a fair tip would be any number between \$6 and \$8. |