

Design Limits Lab

Measure goals, test limits, choose solutions.

HIGH SCHOOL • HS-ETS1-1

HS-ETS1-1 "Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants."

NAME _____

DATE _____

GOALS AND LIMITS

A criterion is a measurable goal, such as a minimum number of people served. A constraint is a limit, such as a maximum cost or time. Calculate the target or limit, then compare the design's value to it.

WORKED EXAMPLE

A relief-kit design has a \$1,200 budget. The team must keep \$150 for delivery. A kit plan costs \$1,025. Does the plan fit the cost constraint?

1. Available for kits = $\$1,200 - \150 .
2. Available for kits = $\$1,050$.
3. $\$1,025$ is less than $\$1,050$.

Answer: Yes. The plan is \$25 under the cost constraint.

PRACTICE 4 problems

- 1** A clean-water system must serve at least 85% of 640 households. What is the minimum number of households it must serve?

ANSWER _____

- 2** A project has a cost cap of \$950. It has already spent \$728. How much more can it spend?

ANSWER _____

- 3** An air filter must reduce 500 mg of pollution by 30%. What is the greatest amount of pollution that may remain?

ANSWER _____

- 4** A battery design may use no more than $\frac{3}{10}$ of a 70 L storage tank. It uses 18 L. Does it meet the constraint? If yes, what is the maximum allowed amount?

ANSWER _____

APPLY IT Show your work

- 1** A student team designs solar phone-charging lockers for a disaster shelter. The lockers must charge at least 84 phones each day and cost no more than \$1,500. The plan charges 96 phones, with \$1,120 for panels and \$310 for installation. Does it meet both quantitative requirements? The lockers must also be usable by wheelchair users. What qualitative requirement still needs to be checked?

WORK SPACE

ANSWER _____

- 2** A cafeteria wants to divert at least $\frac{3}{4}$ of 360 lb of food waste each week while using no more than 48 worker-hours. A compost plan diverts 288 lb and needs 52 worker-hours. Does the plan qualify?

WORK SPACE

ANSWER _____

CHALLENGE One step up

A coastal city needs flood-alert stations that reach at least 900 homes. Each station reaches 75 homes. Each station costs \$140 plus \$35 for installation, and the budget cap is \$2,200. What is the minimum number of stations needed? What is their total cost, and does the design fit the budget? Explain using numbers.

WORK SPACE AND ANSWER

PART 1 • PRACTICE

#	PROBLEM	ANSWER
1	A clean-water system must serve at least 85% of 640 households. What is the minimum number of households it must serve?	544 households
2	A project has a cost cap of \$950. It has already spent \$728. How much more can it spend?	\$222
3	An air filter must reduce 500 mg of pollution by 30%. What is the greatest amount of pollution that may remain?	350 mg
4	A battery design may use no more than 3/10 of a 70 L storage tank. It uses 18 L. Does it meet the constraint? If yes, what is the maximum allowed amount?	Yes; 21 L

PART 2 • APPLY IT

- Yes. The plan charges 96 phones and costs \$1,430. Wheelchair usability still needs to be checked.** Compare 96 with the minimum of 84. Add \$1,120 and \$310, then compare \$1,430 with the \$1,500 cap.
- No. It meets the diversion goal but exceeds the worker-hour constraint by 4 hours.** Three-fourths of 360 lb is 270 lb, so 288 lb meets that criterion. However, 52 hours is greater than the 48-hour limit.

CHALLENGE

12 stations are needed because $900 / 75 = 12$. Each station costs \$175, so 12 stations cost \$2,100. The design fits the \$2,200 budget by \$100.

Accept equivalent money notation and correct units. For comparison items, require students to identify both the calculated threshold and whether the design meets or violates it.