LESSON MAKER PRO

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 success goal: quantitative goals use numbers; qualitative goals describe qualities such as understandable instructions. A constraint limits a solution, such as available money, time or materials. Analyze who needs help and what they need before specifying and justifying goals and limits. Then use calculations to evaluate proposed designs.

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 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 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

Global challenge: communities need reliable warnings of dangerous floods. In this fictional city, 900 homes are at risk; some residents cannot hear sirens, some lack internet, and residents want clear instructions. Only $2,200 and two weeks are available. Before evaluating a plan, specify and justify one quantitative and one qualitative success criterion plus a money and a time constraint. Link each to the brief. Then evaluate stations serving 75 different homes each, costing $140 plus $35 installation each: find the minimum number, total cost and budget margin. State which of your other requirements still needs evidence. Continue on separate paper if needed.

WORK SPACE AND ANSWER

ANSWER KEY # Design Limits Lab

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

1. **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.
2. **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

Example specification: reach all 900 at-risk homes (coverage criterion); provide understandable instructions through accessible methods that do not rely only on hearing or internet (qualitative criterion); cost at most $2,200 and be ready within two weeks (constraints). Each follows a stated need or available resource. Twelve stations cost 12 × $175 = $2,100, leaving $100. Coverage and budget pass under the stated nonoverlapping-coverage assumption. The figures do not establish accessible, understandable delivery or readiness within two weeks; those require testing/scheduling evidence.

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. Assess learner-specified, justified qualitative and quantitative goals and limits, not arithmetic alone. Accept other defensible criteria grounded in the brief. The city and costs are classroom assumptions, not real emergency-planning guidance.