Units Quantities and Descriptive Modeling

Name: _____	Date: _____	Score: _____ / 36

Quick Review

Dimensional analysis is the trick of treating units like factors that can cancel. To convert miles to feet, multiply by $\frac{5280\text{ ft}}{1\text{ mi}}$: the "miles" cancel and "feet" is left. Stack conversion factors in a chain when you need to change two units at once (like miles per hour to feet per second). When you read a graph, **check the axis label** — "Population (millions)" means each unit on the axis is a million people, and a reading of 7.8 means $7{,}800{,}000$. In a formula like $C = 0.12k + 15$ where C is dollars and k is kilowatt-hours, the coefficient 0.12 carries the units \$/kWh so that $0.12k$ ends up in dollars. **Choosing units**: pick the unit that makes the numerical value readable. Pencils are well-described in centimeters, not kilometers. Volume always shows up in cubic units; area in square units; length in plain units.

PRACTICE

Compute the quantity in the requested units. Cancel units as you go.

1. A bakery uses the formula $F = 250 \cdot \frac{m}{12}$ to find how many grams of flour it needs to bake m muffins. How many grams of flour are needed for 36 muffins? _____

2. A bar graph's vertical axis is labeled "Population (millions)." The table lists the bar heights for four cities. What actual population does City C's bar represent? _____

city	bar height
A	2.1
B	5.4
C	7.8
D	3.0

3. A car travels at 12 km/h for 30 minutes. How far does it travel, in meters? _____

4. A construction crew needs to report the diameter of a rebar (a steel rod used to reinforce concrete). Which unit is the most reasonable choice: millimeters, meters, or kilometers? _____

5. The table gives the fuel a car uses on several trips at 8 miles per gallon. Following the same rate, how many gallons does a 600-mile trip use? _____

distance (mi)	fuel (gal)
80	10
240	30
600	?

6. The volume of a sphere is given by $V = \frac{4}{3}\pi r^3$, where r is measured in meters. What are the units of V? _____

7. A bakery buys 48 boxes of flour. Each box weighs $\frac{3}{4}$ pound, and flour costs $\$2.10$ per pound. What is the total cost? _____

8. Which unit is most appropriate for reporting the mass of an adult human: grams, kilograms, or tons? _____

9. An electric bill is given by $C = 0.12k + 15$, where C is the cost in dollars and k is the energy used in kilowatt-hours. What are the units of the coefficient 0.12? _____

10. A baseball is clocked at 45 feet per second leaving the pitcher's hand. Convert that speed to miles per hour, rounded to the nearest tenth. _____

11. A hiking trail is 5 kilometers long. How many meters is that? _____

12. A movie marathon lasts 120 minutes. How many hours is that? _____

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13. The table converts a few durations from hours to seconds. Using the same rate, how many seconds is a 2.5-hour workout? _____

hours	seconds
1	3,600
2	7,200
2.5	?

14. A square garden has a side length of 4 meters. What is its area in square centimeters? _____
15. A block has a mass of 5 kilograms and a volume of 2 cubic meters. What is its density, in kg/m^3? _____
16. Strawberries cost $\$3.50$ per pound at a farmers' market. How much do 2.4 pounds of strawberries cost? _____
17. A sprinter runs 100 meters in 12.5 seconds. What is the sprinter's average speed in meters per second? _____
18. A rectangular shipping box measures 3 m long, 2 m wide, and 1.5 m tall. What is its volume in cubic meters? _____
19. Which unit is most appropriate for reporting how long a marathon runner takes to finish the race: seconds, hours, or days? _____
20. The perimeter of a rectangle is given by $P = 2(l + w)$. If $l = 8$ ft and $w = 5$ ft, what is the perimeter in feet? _____

Word Problems

21. Flour boxes weigh $\frac{3}{4}$ lb each. A bakery buys 48 boxes at $\$2.10$/lb. What is the cost? _____
22. Convert 45 feet per second to miles per hour. Round to the nearest tenth. _____
23. A 25 m by 10 m by 2 m pool fills at 50 L/min. How many hours will it take? (Use 1 m$^3 = 1000$ liters.) _____
24. For $C = 0.12k + 15$, interpret 0.12 and 15, then find the bill for 850 kWh. _____

Additional Practice

25. Convert 3.6 kilometers to meters. _____
26. Convert 540 seconds to minutes. _____
27. A tank holds 2.4 m^3. How many liters is that? _____
28. A runner travels 400 meters in 50 seconds. What is the speed? _____
29. A rectangle is 7 ft by 4 ft. What is its perimeter? _____
30. A box measures 5 cm by 4 cm by 3 cm. What is its volume? _____
31. For $C = 0.09k + 12$, find the bill for 300 kWh. _____
32. Best unit for a pencil length: millimeters, centimeters, or kilometers? _____
33. Convert 2.5 hours to minutes. _____
34. An object has mass 24 kg and volume 8 m^3. Find its density. _____
35. A square has side length 12 cm. What is its area? _____
36. Convert 72 km/h to meters per second. _____

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Answer Keys

1. 750 g
2. 7,800,000
3. 6,000 m
4. millimeter
5. 75 gal
6. m^3
7. \$75.60
8. kilogram
9. \$/kWh
10. 30.7 mi/hr
11. 5,000 m
12. 2 hr
13. 9,000 sec
14. 160,000 cm^2
15. 2.5 kg/m^3
16. \$8.40
17. 8 m/s
18. 9 m^3
19. hours
20. 26 ft
21. \$75.60
22. 30.7 mi/hr
23. $\frac{500}{3}$ hours $\approx$ 166.7 hours
24. \$117.00

Additional Practice Answers

25. 3,600 m
26. 9 min
27. 2,400 L
28. 8 m/s
29. 22 ft
30. 60 cm^3
31. \$39.00
32. centimeters
33. 150 min
34. 3 kg/m^3
35. 144 cm^2
36. 20 m/s

Additional Practice: Answers for all numbered items, including the added practice, are shown in the grid above.

Step-by-Step Explanations

1. A careful way to see it: $F = 250(36/12) = 250(3) = 750$ grams. The fraction $m/12$ scales the base recipe up by a factor of 3 for 36 muffins. That gives a quick check on the answer.

2. The axis label says each unit is one million, so multiply the height by $1{,}000{,}000$. City C: $7.8 \times 10^6 = 7{,}800{,}000$ people. Reading the bare number 7.8 off the axis without the label would be off by a factor of a million.

3. One steady path is: 30 min $= 0.5$ hr. Distance: $12(0.5) = 6$ km. Then $6 \cdot 1000 = 6000$ meters. That gives a quick check on the answer.

4. Rebars are small — a few millimeters across. mm gives a readable, precise number. Centimeters lose precision, meters and kilometers are absurd.

5. Every row divides the miles by 8 mi/gal. So $600 \div 8 = 75$ gallons. The conversion factor $\frac{1\ \text{gal}}{8\ \text{mi}}$ cancels the miles and leaves gallons.

6. Cubing the radius cubes its unit too. π and $\frac{4}{3}$ are dimensionless, so V ends up in m^3.

7. Boxes to pounds first: $48 \cdot \frac{3}{4} = 36$ pounds. Pounds to dollars: $36 \cdot 2.10 = \$75.60$. (The units track: boxes $\to$ pounds $\to$ dollars.)

8. Start with the key idea: 50–100 kg is a readable range. Tons are too big, grams give awkwardly large numbers (like $70{,}000$ g). That gives a quick check on the answer.

9. To turn kWh into dollars, the coefficient must be in dollars per kWh. Check: $0.12\ \frac{\$}{\text{kWh}} \cdot k$ kWh $= 0.12k$ dollars. ✓

10. Keep the rule visible: Chain: $45\ \frac{\text{ft}}{\text{s}} \cdot \frac{3600\ \text{s}}{1\ \text{hr}} \cdot \frac{1\ \text{mi}}{5280\ \text{ft}} = \frac{45 \cdot 3600}{5280} \approx 30.68 \to 30.7$ mph. That gives a quick check on the answer.

11. One steady path is: 1 km $= 1000$ m, so $5 \cdot 1000 = 5000$ m. This is the part to check before moving on, because it keeps the answer tied to the original question.

12. Start with the key idea: 1 hr $= 60$ min, so $120 \div 60 = 2$ hours. This is the part to check before moving on, because it keeps the answer tied to the original question.

13. A careful way to see it: Each hour is $3{,}600$ seconds (that's 60×60). So $2.5 \cdot 3600 = 9{,}000$ seconds. That gives a quick check on the answer.

14. Keep the rule visible: 4 m $= 400$ cm. Area: $400^2 = 160{,}000$ cm^2. (The unit gets squared too — that's why the number jumps so much.) That gives a quick check on the answer.

15. One steady path is: Density is mass divided by volume: $\frac{5}{2} = 2.5$ kg/m^3. This is the part to check before moving on, because it keeps the answer tied to the original question.

16. Start with the key idea: $2.4 \cdot 3.50 = 8.40$ dollars. Pounds cancel out: lb $\cdot \frac{\$}{\text{lb}} = \$$. This is the part to check before moving on, because it keeps the answer tied to the original question.

17. A careful way to see it: Speed is distance over time: $\frac{100}{12.5} = 8$ m/s. This is the part to check before moving on, because it keeps the answer tied to the original question.

18. Keep the rule visible: $3 \cdot 2 \cdot 1.5 = 9$. Units multiply too: m $\cdot$ m $\cdot$ m $= m^3$. This is the part to check before moving on, because it keeps the answer tied to the original question.

19. Marathons take 2–4 hours typically. Hours give a readable number; seconds (around 9000) is large and awkward, days is silly.

20. Start with the key idea: $2(8 + 5) = 2(13) = 26$ feet. Perimeter and side length share the same unit (linear), unlike area which gets squared. That gives a quick check on the answer.

21. Walk the units. 48 boxes $\cdot \frac{3}{4}\ \frac{\text{lb}}{\text{box}} = 36$ pounds (boxes cancel). Then 36 lb $\cdot 2.10\ \frac{\$}{\text{lb}} = \$75.60$ (pounds cancel). The cost is \$75.60.

22. Two conversions in a chain. Seconds to hours (multiply by 3600) and feet to miles (divide by 5280): $45 \cdot \frac{3600}{5280} = \frac{162000}{5280} \approx 30.68$. Round to 30.7 mph.

23. Volume: $25 \cdot 10 \cdot 2 = 500$ m^3. Convert to liters: $500 \cdot 1000 = 500{,}000$ liters. Time at 50 L/min: $\frac{500{,}000}{50} = 10{,}000$ minutes. Convert to hours: $\frac{10{,}000}{60} = \frac{500}{3} \approx 166.7$ hours — a week of nonstop filling.

24. The 15 is a flat fee in dollars — the base charge that applies even at zero usage. The 0.12 is in dollars per kWh, the rate per unit of energy. For 850 kWh: $0.12(850) + 15 = 102 + 15 = 117$. The bill is \$117.00.

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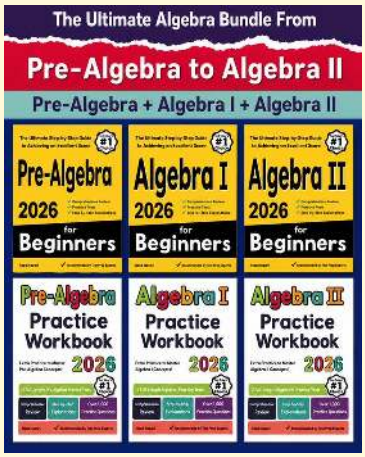

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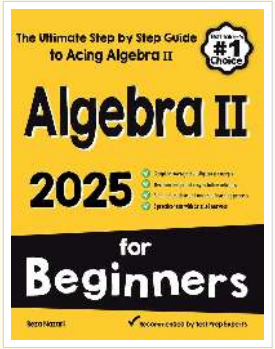

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