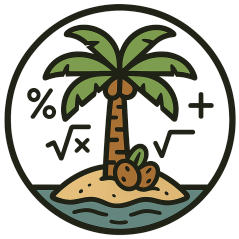

Dessert Isle Unit Analysis

Stranded Standards for Coconauts

Mr. Merrick

On the fabled *Dessert Isle*, shipwrecked scientist pirates standardized measurement using whatever they had: coconuts, bananas, ropes, hammocks, and drumbeats. These **Dessert Units** are *made up but internally consistent*. Your job is to apply unit analysis to convert between Dessert Units and familiar SI/US units, and to chain conversions through density, energy, power, and time. Keep the **Master Table** and the **Data Box** open while you work.

Master Table

Quantity	Dessert Unit (symbol)	Equivalence (exact unless noted)
Length		
Banana (ba)	1 ba	= 0.20 m
Palm (pl)	1 pl	= 0.50 m
Coconut rope (crp)	1 crp	= 2.00 m
Island mile (imi)	1 imi	= 800 m
Area		
Hammock (hmk)	1 hmk	= 2.0 m^2
Sandpatch (spd)	1 spd	= 1.5 m^2
Leaf-mat (lmt)	1 lmt	= 0.50 m^2
Volume		
Coconut shell (csh)	1 csh	= 0.60 L
Gourd (grd)	1 grd	= 2.4 L = 4 csh
Island barrel (ibr)	1 ibr	= 25 L ≈ 6.58 US gal
Mass		
Coconut (cn)	1 cn	= 1.40 kg
Mango (mgo)	1 mgo	= 0.35 kg = 350 g
Crab (crb)	1 crb	= 0.12 kg
Stone (stn)	1 stn	= 2.50 kg
Time		
Drumbeat (db)	1 db	= 0.75 s
Sunset (sst)	1 sst	= 12 min = 720 s
Nap (np)	1 np	= 20 min
Tide (td)	1 td	= 5 h = 300 min
Derived / Reference		
Scurry (scy)	1 scy	= (1 pl)/(1 db) = $\frac{0.50\text{ m}}{0.75\text{ s}} = 0.667$ m/s
Firechip (fch)	1 fch	= 1.00 MJ = 10^6 J
Torch (trc)	1 trc	= 50 W = 50 J/s
Coco-milk density	ρ_{cmlk}	= 1050 kg/m^3 (use when cited)
Dry wood energy (ref)	e_{wood}	≈ 16 MJ/kg (use when cited)

Dessert Isle Data Box: Quick Equivalences

1 L = 1000 mL = 1000 cm^3; 1 m^3 = 1000 L
1 in = 2.54 cm; 1 ft = 0.3048 m; 1 mi = 1609 m
1 US gal = 3.785 L; 1 lb = 0.4536 kg
1 kWh = 3.6×10^6 J; 1 BTU ≈ 1055.06 J

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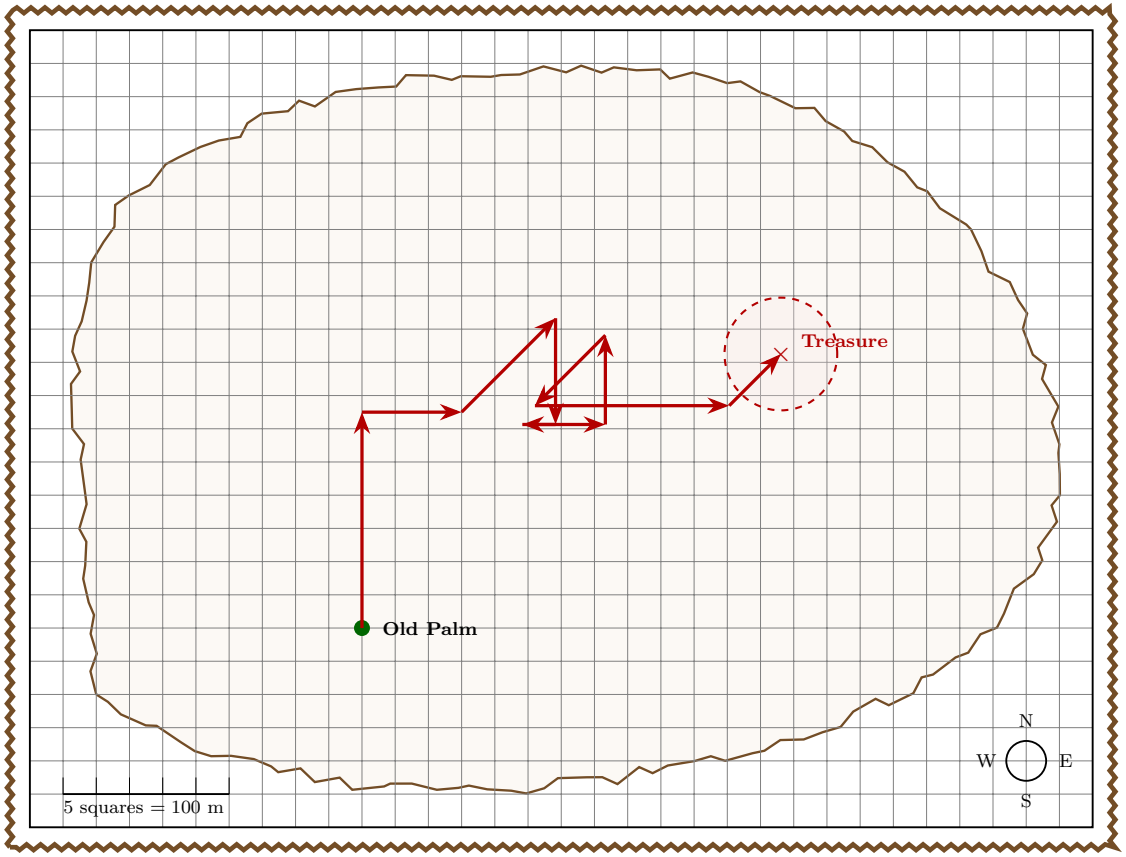
Captain Pi-rate Gaussbeard has left movement instructions. Convert each instruction to *squares*. Mark the treasure with an ×.



1. From the **Old Palm**, walk **260 pl** straight **north**.

$$260\ \text{pl} \times \frac{0.50\ \text{m}}{1\ \cancel{\text{pl}}} \times \frac{1\ \text{square}}{20\ \cancel{\text{m}}} = \mathbf{6.5}\ \text{squares (N)}$$

2. Then go **300 ba east**.

$$300\ \text{ba} \times \frac{0.20\ \text{m}}{1\ \cancel{\text{ba}}} \times \frac{1\ \text{square}}{20\ \cancel{\text{m}}} = \mathbf{3.0}\ \text{squares (E)}$$

3. Next, head **40 crp** toward the **northeast** at 45°.

$$40\ \text{crp} \times \frac{2.00\ \text{m}}{1\ \cancel{\text{crp}}} \times \frac{1\ \text{square}}{20\ \cancel{\text{m}}} = \mathbf{4.0}\ \text{squares @ 45° (NE)}$$

4. Travel **0.08 imi south**.

$$0.08\ \text{imi} \times \frac{800\ \text{m}}{1\ \cancel{\text{imi}}} \times \frac{1\ \text{square}}{20\ \cancel{\text{m}}} = \mathbf{3.2}\ \text{squares (S)}$$

5. Go **100 ba west**.

$$100\ \text{ba} \times \frac{0.20\ \text{m}}{1\ \cancel{\text{ba}}} \times \frac{1\ \text{square}}{20\ \cancel{\text{m}}} = \mathbf{1.0}\ \text{squares (W)}$$

6. Move **east** at **25 crp/min** for **60 s**.

$$\frac{25\ \text{crp}}{1\ \text{min}} \times \frac{2.00\ \text{m}}{1\ \text{crp}} \times \frac{1\ \text{min}}{60\ \text{s}} \times 60\ \text{s} \times \frac{1\ \text{square}}{20\ \text{m}} = \mathbf{2.5}\ \text{squares (E)}$$

7. Go **north** for **0.08 sst** at **1.4 scy**.

$$0.08\ \text{sst} \times \frac{720\ \text{s}}{1\ \text{sst}} \times 1.4\ \text{scy} \times \frac{0.667\ \text{m/s}}{1\ \text{scy}} \times \frac{1\ \text{square}}{20\ \text{m}} = \mathbf{2.688}\ \text{squares (N)}$$

8. Head **30 crp** toward the **southwest** at 45°.

$$30\ \text{crp} \times \frac{2.00\ \text{m}}{1\ \text{crp}} \times \frac{1\ \text{square}}{20\ \text{m}} = \mathbf{3.0}\ \text{squares @ 45° (SW)}$$

9. For **180 db** at **1.3 scy**, move **east**.

$$180\ \text{db} \times \frac{0.75\ \text{s}}{1\ \text{db}} \times 1.3\ \text{scy} \times \frac{0.667\ \text{m/s}}{1\ \text{scy}} \times \frac{1\ \text{square}}{20\ \text{m}} \approx \mathbf{5.85}\ \text{squares (E)}$$

10. Finally, advance **22 crp** toward the **northeast** at 45°.

$$22\ \text{crp} \times \frac{2.00\ \text{m}}{1\ \text{crp}} \times \frac{1\ \text{square}}{20\ \text{m}} = \mathbf{2.2}\ \text{squares @ 45° (NE)}$$

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Practice — Dessert Isle Conversions

Use only the Master Table and the Data Box. Show unit cancellation at every step.

1. **Banana highway.** The beach loop is 1.75 imi. Express its length in palms (pl) and in bananas (ba).

   Solution.

$$1.75 \text{ imi} \times \frac{800 \text{ m}}{1 \cancel{\text{ imi}}} = 1400 \text{ m}.$$

$$1400 \text{ m} \times \frac{1 \text{ pl}}{0.50 \cancel{\text{ m}}} = 2800 \text{ pl}, \qquad 1400 \text{ m} \times \frac{1 \text{ ba}}{0.20 \cancel{\text{ m}}} = 7000 \text{ ba}.$$

2. **Hammock zoning with conversion.** A rectangular lot is 18 pl by 35 ba. Compute its area in m^2, hmk, and ft^2.

   Solution.

$$18 \text{ pl} \times \frac{0.50 \text{ m}}{1 \cancel{\text{ pl}}} = 9.0 \text{ m}, \qquad 35 \text{ ba} \times \frac{0.20 \text{ m}}{1 \cancel{\text{ ba}}} = 7.0 \text{ m}.$$

$$A = 9.0 \text{ m} \times 7.0 \text{ m} = 63.0 \text{ m}^2.$$

$$63.0 \text{ m}^2 \times \frac{1 \text{ hmk}}{2.0 \cancel{\text{ m}^2}} = 31.5 \text{ hmk}, \qquad 63.0 \text{ m}^2 \times \frac{10.764 \text{ ft}^2}{1 \cancel{\text{ m}^2}} = 6.78 \times 10^2 \text{ ft}^2.$$

3. **Coco-milk mass from volume.** A keg holds 12 grd of coco-milk. Using ρ_{cmlk}, find the mass in kg and in mangos (mgo).

   Solution.

$$12 \text{ grd} \times \frac{2.4 \text{ L}}{1 \cancel{\text{ grd}}} = 28.8 \text{ L} \times \frac{1 \text{ m}^3}{1000 \cancel{\text{ L}}} = 2.88 \times 10^{-2} \text{ m}^3.$$

$$m = \rho V = \left(1050 \frac{\text{kg}}{\cancel{\text{m}^3}}\right)\left(2.88 \times 10^{-2} \cancel{\text{ m}^3}\right) = 30.2 \text{ kg}.$$

$$30.2 \text{ kg} \times \frac{1 \text{ mgo}}{0.35 \cancel{\text{ kg}}} = 86.3 \text{ mgo}.$$

4. **Flow over a tide.** A still produces 4.2 ibr every tide. Report the average flow in L/s and in US gal/min.

   Solution.

$$4.2 \text{ ibr} \times \frac{25 \text{ L}}{1 \cancel{\text{ ibr}}} = 105 \text{ L per td}. \qquad 1 \text{ td} \times \frac{5 \text{ h}}{1 \cancel{\text{ td}}} \times \frac{3600 \text{ s}}{1 \cancel{\text{ h}}} = 18{,}000 \text{ s}.$$

$$\frac{105 \text{ L}}{18{,}000 \text{ s}} = 5.83 \times 10^{-3} \text{ L/s}.$$

$$105 \text{ L} \times \frac{1 \text{ US gal}}{3.785 \cancel{\text{ L}}} = 27.7 \text{ US gal per td} \quad \Rightarrow \quad \frac{27.7 \text{ US gal}}{300 \text{ min}} = 9.23 \times 10^{-2} \text{ US gal/min}.$$

5. **Pace to mph.** A runner holds 2.0 scy for one sunset (sst). Give the distance in meters and the average speed in mph.

   Solution.

$$2.0\ \text{scy} \times \frac{2}{3}\ \frac{\text{m}}{\text{s scy}} = \frac{4}{3}\ \frac{\text{m}}{\text{s}}. \qquad 1\ \text{sst} \times \frac{12\ \text{min}}{1\ \cancel{\text{sst}}} \times \frac{60\ \text{s}}{1\ \cancel{\text{min}}} = 720\ \text{s}.$$

$$d = \left(\frac{4}{3}\ \frac{\text{m}}{\cancel{\text{s}}}\right)(720\ \cancel{\text{s}}) = 960\ \text{m}. \qquad \frac{4}{3}\ \frac{\text{m}}{\text{s}} \times \frac{2.237\ \text{mph}}{1\ \cancel{\text{m/s}}} = 2.98\ \text{mph}.$$

6. **Fire to light (energy chain).** The beacon runs at 3.5 trc for 1.5 td. How many firechips (fch), kWh, and BTU is that?

   Solution.

$$3.5\ \text{trc} \times \frac{50\ \text{J/s}}{1\ \cancel{\text{trc}}} = 175\ \frac{\text{J}}{\text{s}}. \qquad 1.5\ \text{td} \times \frac{5\ \text{h}}{1\ \cancel{\text{td}}} \times \frac{3600\ \text{s}}{1\ \cancel{\text{h}}} = 27{,}000\ \text{s}.$$

$$E = \left(175\ \frac{\text{J}}{\cancel{\text{s}}}\right)(27{,}000\ \cancel{\text{s}}) = 4.73 \times 10^6\ \text{J}.$$

$$4.73{\times}10^6\ \text{J} \times \frac{1\ \text{fch}}{10^6\ \cancel{\text{J}}} = 4.73\ \text{fch}, \quad 4.73{\times}10^6\ \text{J} \times \frac{1\ \text{kWh}}{3.6 \times 10^6\ \cancel{\text{J}}} = 1.31\ \text{kWh}, \quad 4.73{\times}10^6\ \text{J} \times \frac{1\ \text{BTU}}{1055.06\ \cancel{\text{J}}} = 4.48{\times}10^3\ \text{B}$$

7. **Wood-to-heat estimate.** If dry wood has $e_{\text{wood}} \approx 16$ MJ/kg, how many kilograms of wood are equivalent to 18 fch? Also report in pounds.

   Solution.

$$18\ \text{fch} \times \frac{1.00\ \text{MJ}}{1\ \cancel{\text{fch}}} = 18\ \text{MJ} \times \frac{1\ \text{kg}}{16\ \cancel{\text{MJ}}} = 1.125\ \text{kg}. \qquad 1.125\ \text{kg} \times \frac{2.20462\ \text{lb}}{1\ \cancel{\text{kg}}} = 2.48\ \text{lb}.$$

8. **Raft volume.** A rectangular raft is 40 pl long, 60 ba wide, and 12 ba thick. Find its total volume in cubic meters and in liters.

   Solution.

$$40\ \text{pl} \times \frac{0.50\ \text{m}}{1\ \cancel{\text{pl}}} = 20\ \text{m}, \qquad 60\ \text{ba} \times \frac{0.20\ \text{m}}{1\ \cancel{\text{ba}}} = 12\ \text{m}, \qquad 12\ \text{ba} \times \frac{0.20\ \text{m}}{1\ \cancel{\text{ba}}} = 2.4\ \text{m}.$$

$$V = 20\ \text{m} \times 12\ \text{m} \times 2.4\ \text{m} = 576\ \text{m}^3.$$

$$576\ \text{m}^3 \times \frac{1000\ \text{L}}{1\ \cancel{\text{m}^3}} = \mathbf{5.76 \times 10^5}\ \text{L}.$$

9. **Market basket (mixed units).** A trader brings 18 crb, 12 mgo, and 6 cn. Find the total mass in kg and in stones (stn).

   Solution.

$$18\ \text{crb} \times \frac{0.12\ \text{kg}}{1\ \cancel{\text{crb}}} = 2.16\ \text{kg}, \quad 12\ \text{mgo} \times \frac{0.35\ \text{kg}}{1\ \cancel{\text{mgo}}} = 4.20\ \text{kg}, \quad 6\ \text{cn} \times \frac{1.40\ \text{kg}}{1\ \cancel{\text{cn}}} = 8.40\ \text{kg}.$$

$$m_{\text{total}} = 2.16 + 4.20 + 8.40 = 14.76\ \text{kg}, \qquad 14.76\ \text{kg} \times \frac{1\ \text{stn}}{2.50\ \cancel{\text{kg}}} = 5.90\ \text{stn}.$$

10. **Lagoon in bananas (two ways).** A lagoon is labelled 0.62 imi. Compute its length in bananas (ba) using (i) direct conversion, and (ii) via meters then bananas.

Solution.

$$\text{(i)}\quad 0.62\ \text{imi} \times \frac{800\ \text{m}}{\cancel{1\ \text{imi}}} \times \frac{1\ \text{ba}}{0.20\ \cancel{\text{m}}} = 2480\ \text{ba}.$$

$$\text{(ii)}\quad 0.62\ \text{imi} \times \frac{800\ \text{m}}{\cancel{1\ \text{imi}}} = 496\ \text{m}, \qquad 496\ \text{m} \times \frac{1\ \text{ba}}{0.20\ \cancel{\text{m}}} = 2480\ \text{ba}.$$

11. **From barrels to pace.** A drip system delivers 0.85 ibr per nap. How many csh per minute is that? Then, if each person drinks 3 csh per sunset, how many people can you serve continuously?

Solution.

$$0.85\ \text{ibr} \times \frac{25\ \text{L}}{\cancel{1\ \text{ibr}}} = 21.25\ \text{L per np}, \qquad 1\ \text{np} = 20\ \text{min}.$$

$$\frac{21.25\ \text{L}}{20\ \text{min}} \times \frac{1\ \text{csh}}{0.60\ \cancel{\text{L}}} = 1.77\ \text{csh/min}.$$

$$1.77\ \frac{\text{csh}}{\text{min}} \times 12\ \text{min per sst} = 21.2\ \text{csh/sst}, \qquad 21.2\ \text{csh} \times \frac{1\ \text{person}}{3\ \cancel{\text{csh}}} \approx 7\ \text{people}.$$

12. **Cart cruise.** A cart moves at 2.5 scy for one tide. How far does it travel in meters and in island miles (imi)?

Solution.

$$1\ \text{scy} = \frac{1\ \text{pl}}{1\ \text{db}} = \frac{0.50\ \text{m}}{0.75\ \text{s}} = \frac{2}{3}\ \tfrac{\text{m}}{\text{s}}.$$

$$v = 2.5\ \text{scy} \times \frac{2}{3}\ \frac{\text{m/s}}{\text{scy}} = \frac{5}{3}\ \tfrac{\text{m}}{\text{s}}. \qquad t = 1\ \text{td} \times \frac{5\ \text{h}}{1\ \text{td}} \times \frac{3600\ \text{s}}{1\ \text{h}} = 18{,}000\ \text{s}.$$

$$d = v\,t = \left(\frac{5}{3}\ \frac{\text{m}}{\text{s}}\right)(18{,}000\ \text{s}) = 30{,}000\ \text{m}.$$

$$30{,}000\ \text{m} \times \frac{1\ \text{imi}}{800\ \text{m}} = \mathbf{37.5}\ \text{imi}. \quad \text{(Also 30,000 m in meters.)}$$