Dessert Isle Unit Analysis

Stranded Standards for Coconauts

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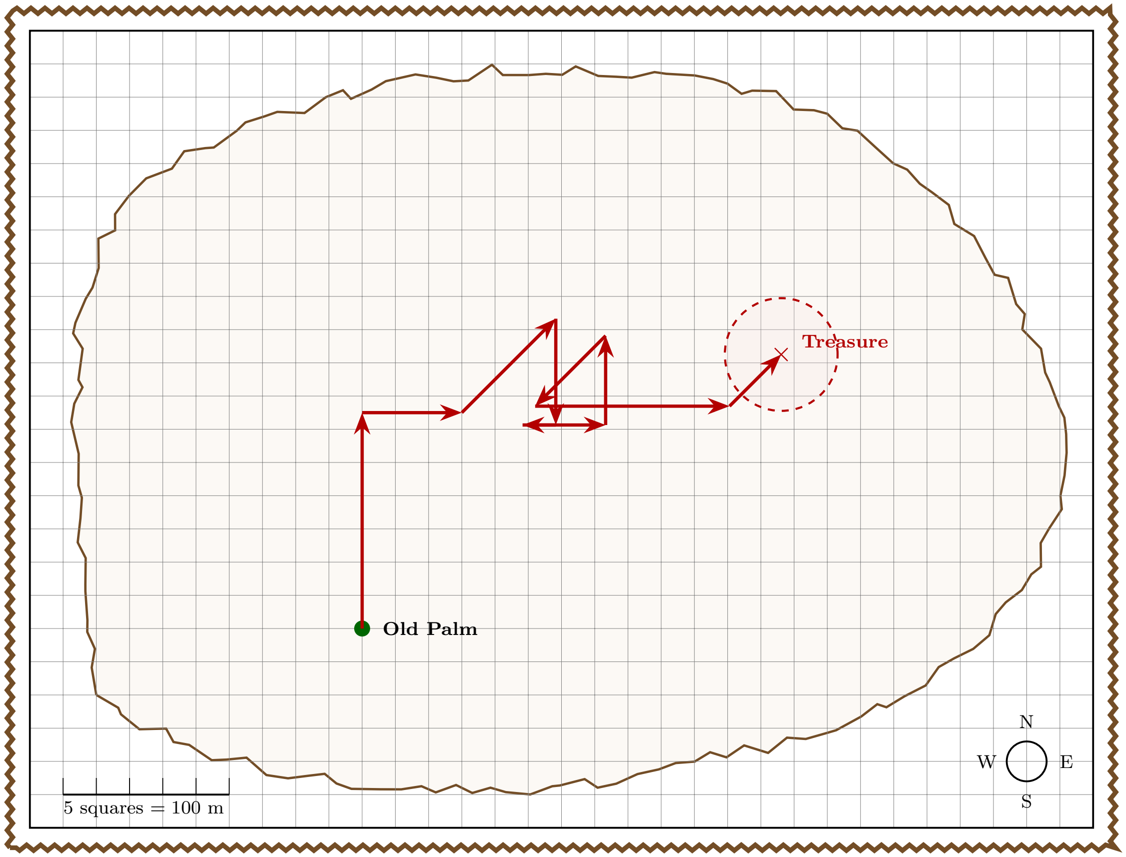
On the fabled *Dessert Isle*, shipwrecked scientist pirates standardized measurement using whatever they had: coconuts, bananas, ropes, hammocks, and drumbeats. These **Dessert Units** are *made up but internally consistent*. Your job is to apply unit analysis to convert between Dessert Units and familiar 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	$= 2.0\ \text{m}^2$
Sandpatch (spd)	1 spd	$= 1.5\ \text{m}^2$
Leaf-mat (lmt)	1 lmt	$= 0.50\ \text{m}^2$
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	$= (1\ \text{pl})/(1\ \text{db}) = \dfrac{0.50\ \text{m}}{0.75\ \text{s}} = 0.667\ \text{m/s}$
Firechip (fch)	1 fch	$= 1.00\ \text{MJ} = 10^6\ \text{J}$
Torch (trc)	1 trc	$= 50\ \text{W} = 50\ \text{J/s}$
Coco-milk density	ρ_{cmlk}	$= 1050\ \text{kg/m}^3$ (use when cited)
Dry wood energy (ref)	e_{wood}	≈ 16 MJ/kg (use when cited)

Dessert Isle Data Box: Quick Equivalences
$1\ \text{L} = 1000\ \text{mL} = 1000\ \text{cm}^3$; $1\ \text{m}^3 = 1000\ \text{L}$
$1\ \text{in} = 2.54\ \text{cm}$; $1\ \text{ft} = 0.3048\ \text{m}$; $1\ \text{mi} = 1609\ \text{m}$
$1\ \text{US gal} = 3.785\ \text{L}$; $1\ \text{lb} = 0.4536\ \text{kg}$
$1\ \text{kWh} = 3.6 \times 10^6\ \text{J}$; $1\ \text{BTU} \approx 1055.06\ \text{J}$

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°.

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

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.

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

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

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.

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

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

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

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.

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

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

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

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.

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

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

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

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.

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

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

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.

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

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

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

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.

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

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.

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

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

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

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.

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

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

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.

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

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

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

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