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Pharmacology and Medical Math for Technicians

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Pharmacology and Medical Math for Technicians

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Why do we (*have to*) learn math?

1. Math is awesome.
2. **Protect the patient.**
   - 560 Medical errors (Wallis et al., 2019)
     - #1 Drug errors
       - Wrong Dose (58%)
     - #2 Failures of communication
   - Outcomes
     - 15% resulted in patient harm
       - temporary patient harm (82%)
       - permanent morbidity or death (8%)
3. Self care.
4. Protect the license.
5. Protect the practice.

Learning Objectives

1. Algebra foundations
2. Patient vitals
   - Rates per minute
   - Averages
   - Temperature
3. Abbreviations and conversions
4. Dosages
   - Basic Rx
   - CRIs
   - Solutions
   - Dilutions
5. Fluid rates
   - AAHA guidelines
   - Maintenance
   - Anesthesia
   - Overload
6. Nutrition Math
7. Anesthesia Math
   - Tidal volume
   - Reservoir bag size
   - Oxygen flow rates

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Algebra Foundations

- Rounding
- Fractions
  - Simplifying
  - Multiplying
  - Dividing
- Exponents
- Order of Operations
- Linear Equations
- Ratios

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Algebra foundations: Rounding

- Round at the end
- If under 1 ml, round to 0.01
- If greater than 1 ml, round to 0.1 (or according to delivery confines)
- Look only to closest digit to the right of the number to be rounded

Example:

0.0949 → 0.09

0.055 → 0.06

0.095 → 0.1

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Algebra foundations: Fractions

The fear of fractions is called fracphobia.

1. Another way to write division.
   - Two of six donuts have chocolate frosting
- 2/6 or $\frac{2}{6}$ ← This line means "divide by"
   - 0.3333
   - 33.33% (33.33 out of 100)
1. Any number converts to a fraction
   - By placing it over a 1
- $\frac{6}{1}$

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Algebra foundations: Simplifying fractions

A way to easily compare fractions

- Two of six donuts have chocolate frosting

- $\frac{2}{6}$
- Factors of 2: 1, 2
- Factors of 6: 1, 2, 3, 6
- $\frac{2}{6} \rightarrow \frac{2/2}{6/2} = \frac{1}{3}$
- Therefore: $\frac{2}{6} = \frac{1}{3}$

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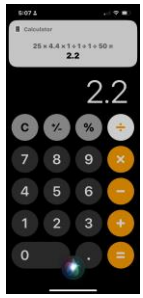
Algebra foundations: Multiplying fractions

1. Multiply the numerators
2. Multiply the denominators
3. Simplify

$$\frac{25}{1} x \frac{4.4}{1} x \frac{1}{50} = \frac{25 \ x \ 4.4 \ x \ 1}{1 \ x \ 1 \ x \ 50}$$

$= \frac{110}{50}$ ← This line means "divide by"

$= 2.2$



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Algebra foundations: Dividing fractions

Use reciprocals to divide fractions (multiply by the reciprocal)

- Reciprocal of $\frac{2}{6}$ is $\frac{6}{2}$
- Tracey + Kelly both want chocolate donuts. What % of the donuts does each LVT get?
- $\frac{2\ chocolate\ donuts}{6\ total\ donuts} \div 2$ LVTs
- $2 = \frac{2}{1}$
- Reciprocal of $\frac{2}{1} = \frac{1}{2}$
- Therefore, $\frac{2}{6} \times \frac{1}{2} = \frac{2 \times 1}{6 \times 2} = \frac{2}{12} = \frac{1}{6}$

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Algebra foundations: Exponents

- A number multiplied by itself a designated number of times
- 2^4
- Base = 2
- Exponent = 4 = Factor
- 2 x 2 x 2 x 2 = 16

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Algebra foundations: Order of Operations

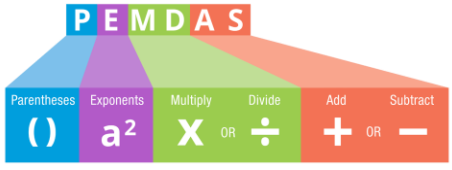

Image courtesy of Mathnasium.com

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Algebra Foundations: Linear Equations

- Using x to substitute an unknown number you want to solve for.
- Treat both sides of the equation equally → no change in value
- Example: 4+x =10
- Isolate the unknown
- Example: $4 + x = 10$

$4 + x - 4 = 10 - 4$

$x = 6$

- Example: $20x = 100$

$\frac{20x}{20} = \frac{100}{20}$

$x = 5$

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Algebra Foundations: Ratios + Proportions

- $\frac{A}{B} = \frac{X}{Y}$ or A:B = X:Y or The ratio of A to B is equal to the ratio of X to Y
- $\frac{1}{4} = \frac{X}{100}$ or 1:4 = x:100
- Shortcut! Cross multiply $\frac{1}{4} \times \frac{X}{100}$ → 100 (1) = 4 (x)
- Isolate x
- 100 = 4x → $\frac{100}{4} = \frac{4x}{4}$
- **25 = x**

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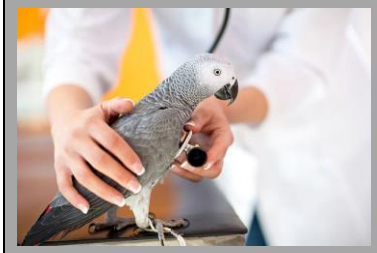
Patient Vitals



1. HR/ RR
2. Temperature
3. BP averages

Image by Getty Images

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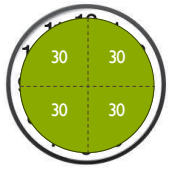
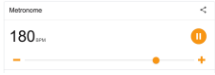
Heart + Respiratory Rate



- Count beats/breaths for 15 seconds
- Multiply by 4
- Example: 30 beats x 4
  = 120 bpm
- Helpful hints:
  1. Beats x 2, x 2
     Example: 30 x 2 = 60, 60 x 2 = 120
  2. Practice with online metronome



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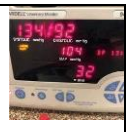
Blood Pressure



- At least 3 NIBP from the patient
- Record the average of 3 in medical record
- Average of a set of numbers = $\frac{\text{the sum of the numbers in the set}}{\text{how many numbers in the set}}$
- Example: An LVT observes the following NIBP readings:

  $\frac{128}{78}$ (96), $\frac{130}{80}$ (95), $\frac{134}{92}$ (104)

  Average of systolic pressure: $\frac{128 + 130 + 134}{3} = \frac{392}{3} = 131$

  Average of diastolic pressure: $\frac{78 + 80 + 92}{3} = \frac{250}{3} = 83$

  Average of MAP: $\frac{96 + 95 + 104}{3} = \frac{295}{3} = 98$

Bruce I 2:00 pm NIBP $\frac{131}{83}$ (98)

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Temperature

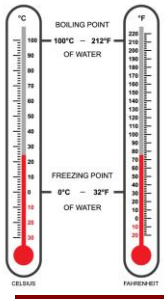
F = (Celsius x 1.8) + 32

F = (Celsius x $\frac{9}{5}$) + 32

Example: Bair hugger
43 C (high)
F = (43 x 1.8) +32
F = 109.4

C = (F -32) ÷ 1.8

Example: 90F
C = (90-32) ÷ 1.8
C = 32 (low)



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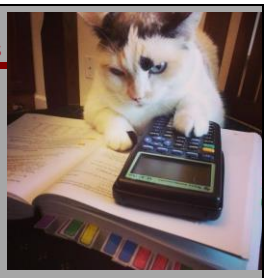
Abbreviations and Conversions

- Common abbreviations
- Common Conversions:
  - Imperial vs. Metric
  - Metric to Metric



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Common Abbreviations

Route:
- PO = per os = by mouth
- SQ (SC) = subcutaneous
- IM = intramuscular
- IV = intravenous
- IO = intraosseous
- ID = intradermal
- IP = intraperitoneal (into the abdominal cavity)

Location:
- OD – right eye
- OS – left eye
- OU – both eyes
- AD – right ear
- AS – left ear
- AU – both ears

Frequency:
- Q or q = every
- H or h = hour
- D or d = day
- s.i.d. = once daily (Q 24 hours)
- b.i.d. = twice daily (Q 12h)
- t.i.d. = three times daily (Q 8h)
- q.i.d. = four times daily (Q 6h)
- q.o.d. = every other day
- PRN or prn = as needed
- STAT = immediately

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Common Conversions

16 oz = 1 lb.

Patients < 10 kgs (22 lb.) weighed on small scale
- pounds (decimal point) fraction of ounces
- Multiply fraction by 16
- 7.9 = 7 pounds 14 oz

2.2 lb. = 1 kg

$$\frac{5\ \text{kg}}{1} \times \frac{2.2\ \text{lb}}{1\ \text{kg}} = 11\ \text{lb.}$$

$$\frac{20\ \text{lb}}{1} \times \frac{1\ \text{kg}}{2.2\ \text{lb.}} = 9.1\ \text{kg}$$

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Common Conversions

1 fluid oz = 30 ml

1 teaspoon = 5 ml

Dilute Rescue Concentrate at a 1:64 ratio

(2 ounces of concentrate per 1 gallon of water)

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Conversions of metric units

x 10 x 10 x 10 x 1000 x 1000

	kilo	hecto	deca	Base unit	deci	centi	milli 10^{-3}			micro 10^{-6}
Volume	kL	1 kL = 10 hL	1 kL = 100 daL	Liter (L)	1 L = 10 dL	1 L = 100 cL	1 L = 1000 mL			
Mass	kg			Gram (g)			1 g = 1000 mg			1 mg = 1000 mcg
Distance	km			Meter (m)			mm			

÷ 10 ÷ 10 ÷ 10 ÷ 10000

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Conversions of metric units

- 1000 mL = 1 L
  - $\frac{1000\ mL}{1\ L}$
- a.k.a. $\frac{\mathbf{1\ L}}{\mathbf{1000\ mL}}$ (reciprocal)
  - If the fluid rate is 250 mL/hr, how many hours will a 1L bag of 0.9% NaCl last?
  - $\frac{1\ L}{1} x \frac{1000\ mL}{1\ L} x \frac{1\ hr}{250\ mL} =$
- $\frac{1\ L}{1} x \frac{1000\ mL}{1\ L} x \frac{1\ hr}{250\ mL} =$
  - $\frac{1 x 1000 x 1\ hr}{1 x 1 x 250} = \frac{1000\ hr}{250} = \frac{4\ hr}{1} = 4$ hours

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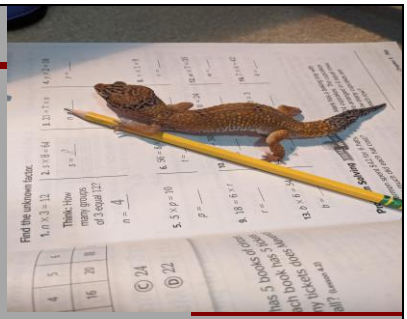
Dosages

- Basic Rx
- CRIs
- Solutions
- Dilutions



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Basic Dose

- Dose = amount of drug at one specific time
- Dosage = amount, number, and frequency of drug over a specified duration
- $\frac{\text{weight} \times \text{dosage}}{\text{concentration}}$
- 5 mg/kg/dose of Trazodone (100 mg/tablet) for a 40 kg patient. How many tablets per dose?
- $\frac{40\ kg}{1} \times \frac{5\ mg}{kg/dose} \times \frac{1\ tablet}{100\ mg} =$
- $\frac{40}{1} \times \frac{5}{1\ dose} \times \frac{1\ tablet}{100} = \frac{40 \times 5 \times 1\ tablet}{1 \times 100\ dose} = \frac{200\ tablet}{100\ dose} = \frac{2\ tablets}{1\ dose}$
- 0.3 mg/kg/dose of methadone (10 mg/ml) for a 24 kg patient. How many ml per dose?
- $\frac{24\ kg}{1} \times \frac{0.3\ mg}{kg/dose} \times \frac{1\ mL}{10\ mg} =$
- $\frac{24}{1} \times \frac{0.3}{1\ dose} \times \frac{1\ mL}{10} = \frac{24 \times 0.3 \times 1\ mL}{1 \times 10\ dose} = \frac{7.2\ mL}{10\ dose} = \frac{0.72\ mL}{1\ dose}$

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Constant Rate Infusions

- What is the CRI rate (ml/hr) for a 20 kg dog prescribed 3 mcg/kg/hr of Fentanyl (50 mcg/ml)?
- $\frac{20\ kg}{1} \times \frac{3\ mcg}{kg/hr} \times \frac{1\ ml}{50\ mcg}$
- $\frac{20}{1} \times \frac{3}{1\ hr} \times \frac{1\ ml}{50}$
- $\frac{20 \times 3 \times 1\ ml}{1 \times hr \times 50} = \frac{60\ ml}{50\ hr} = \frac{1.2\ ml}{hr}$

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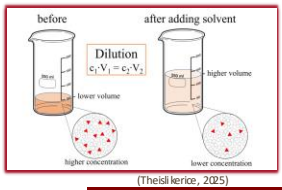
Solutions

- 5% dextrose = 50 mg/ml
  - Percentage = per 100 = x/100
  - If no units defined, assumed to be g/ml
    - 5% = 0.05 g/ml
  - $\frac{0.05\ g}{1\ ml} \times \frac{1000\ mg}{1\ g} = \frac{50\ mg}{1\ ml}$
- Shortcut % to mg/ml
  - Multiply by 10
  - Move decimal 1 place to right
  - 2% lidocaine solution = 20 mg/ml
- Shortcut mg/ml to %
  - Divide by 10
  - Move decimal 1 place to left
  - 9 mg/ml = 0.9% NaCl solution

Dilutions

- Decreasing the concentration of a solution with a diluent
- Concentration and volume of solution 1 = concentration and volume of solution 2
  - $C_1 V_1 = C_2 V_2$
- Common Dilutions
  - Acepromazine
  - Potassium Chloride
  - Metoclopramide
  - Dopamine



(Theisli kerice, 2025)

Dilutions: Acepromazine

Calculate the volume (ml) of 10mg/ml Acepromazine needed to create 10 ml of a 1mg/ml diluted Acepromazine solution.

- C1 = $\frac{10\ mg}{1\ ml}$ V1 = ? C2 = $\frac{1\ mg}{1\ ml}$ V2 = $\frac{10\ ml}{1}$
- $\frac{1\ ml}{10\ mg} \times \frac{10\ mg}{1\ ml} \times V1 = \frac{1\ mg}{1\ ml} \times \frac{10\ ml}{1} \times \frac{1\ ml}{10\ mg}$
- $V1 = \frac{1\ \cancel{mg} \times 10\ ml \times 1\ \cancel{ml}}{1\ \cancel{ml} \times 1 \times 10\ \cancel{mg}} = \frac{10\ ml}{10} = 1\ ml$

Dilutions: KCl

- Common dose : 20-40 mEq/L
- Using a 2 mEq/ml KCL solution, find the volume (ml) of KCL that needs to be added to a 1L bag of fluids to create a final solution of 20 mEq/L.
  - C1 = $\frac{2\ mEq}{ml}$ V1 = ?
  - C2 = $\frac{20\ mEq}{L}$ V2 = 1 L = 1000 ml
  - $\frac{2\ mEq}{ml}$ x V1 = $\frac{20\ mEq}{L}$ x $\frac{1000\ mL}{1}$
  - $\frac{1\ ml}{2\ mEq}$ x $\frac{2\ mEq}{ml}$ x V1 = $\frac{20\ mEq}{L}$ x $\frac{1\ L}{1}$ x $\frac{1\ ml}{2\ mEq}$
  - V1 = $\frac{20\ \cancel{mEq} \times 1\ \cancel{L} \times 1\ ml}{1\ \cancel{L} \times 1 \times 2\ \cancel{mEq}}$ = $\frac{20 \times 1 \times 1\ ml}{1 \times 1 \times 2}$ = $\frac{20\ ml}{2}$
  - V1 = 10 ml

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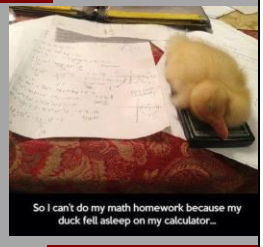
Fluid Rates

**AAHA + 2024 RECOVER increased emphasis **

- Repeat monitoring, correct deficits with individual plan.
- High-volume fluid rates increase the risk of volume overload in anesthetized patients.
- Correct 80% of dehydration deficits within 24 hours before anesthesia when possible.
- Withholding water before anesthesia is generally unnecessary.
- IV fluid administration will not increase GFR in a patient that is hydrated and euvolemic.
- For renal disease patients (IRIS stage 3 or 4)
  - Correct dehydration pre-anesthesia.
  - Monitor blood pressure closely.
  - Avoid excessive fluid infusion to manage hypotension.
- If fluid rates exceed 20 ml/kg during anesthesia, reassess.



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Daily maintenance fluid rate

Daily maintenance fluid rate

Healthy Dogs/Cats 40-60ml/kg/day
- may underestimate small/large pt
- 2-6 ml/kg/hr (dogs)
- 2-3 ml/kg/hr (cats)
  - Most common 2-3 ml/kg/hr (both)

Allometric Formula
- Healthy Dogs: 132 x $kg^{0.75}$ ml/day
- Healthy Cats: 80 x $kg^{0.75}$ ml/day

Sick patients
- (2- 50 kg) → 30 x kg + 70 ml/day
- 70 x $kg^{0.75}$ ml/day

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Dehydration rates

	5%	8%	10%	12%
MM	mild tacky	tacky	significant	
CRT	--	delayed	moderate - significant	
Skin tent	mild	moderate	significant	
Eyes		mild sunken	sunken	
Pulse		weak/rapid	weak	
Other		mild tachycardia possible	tachycardia	shock, hypothermia, life threatening

- Dehydration % assumed to be L/kg
- Correct slowly over 12-24 hours.
- A 3.5 kg cat is 5% dehydrated. Find the dehydration fluid rate (ml/hr) over 24 hours.
- 3.5 kg x 0.05 = $\frac{0.175\ L}{1} x \frac{1000\ mL}{1\ L} = 175$ ml → $\frac{175\ mL}{24\ hrs} = \frac{7.3\ mL}{hr}$

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Replacement rates

- Quantify ongoing losses over a period.
  - 1 gram of weight loss equals 1 mL of fluid lost. (1 kg = 1 L)
- Deliver over 2-3 hours of loss (AAHA, 2024).
- Total fluid rate = maintenance + dehydration + ongoing losses

Calculate a fluid rate for a 5 kg pt with 5% dehydration and 15 ml/3 hours calculated loss.

- Replacement rate: $\frac{15\ mL \div 3}{3\ hr \div 3} = \frac{5\ mL}{hr}$
- Maintenance rate: $\frac{5\ kg}{1} x \frac{2\ ml}{kg/hr} = \frac{10\ mL}{hr}$
- Dehydration rate: 5 kg x 0.08 = $\frac{0.4\ L}{12\ hr} x \frac{1000\ mL}{1\ L} = \frac{400\ mL}{12\ hr} = 33$ ml/hr
- Total fluid rate: $\frac{5\ mL}{hr} + \frac{10\ mL}{hr} + \frac{33\ mL}{hr} = \frac{48\ mL}{hr}$

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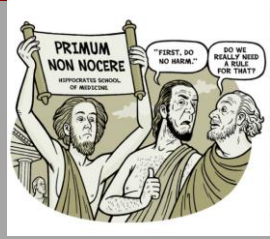
Boluses

"Fluid overload is a potentially life-threatening complication for which no universally effective therapy exists," (AAHA, 2024).

- Overhydration :
  - mild peripheral edema
  - Increased weight (>10%)
- Overload:
  - Respiratory distress,
  - GI dysfunction
  - Renal/hepatic dysfunction



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Boluses

What will your fluid rate per hour be when…

1. Your doctor orders a 200ml NaCl IV bolus over 15 minutes.

$$\frac{200\ ml}{15\ min} \times \frac{60\ min}{1\ hour}$$

$$= \frac{200\ x\ 60\ ml}{15\ hr}$$

= 800 ml/hr

2. Your doctor orders 10ml/kg NaCl IV bolus over 10 minutes for a 25 kg dog.

$$= \frac{25\ kg}{1} \times \frac{10\ ml}{kg/10min} = \frac{250\ ml}{10\ min}$$

$$= \frac{250\ ml}{10\ min} \times \frac{60\ min}{1\ hour}$$

= 1500 ml/hr

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Nutritional Math

- RER
- MER
- Cups per Feeding

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Nutrition Math

RER = Resting Energy Requirement (kcal/day)
- Caloric energy requirement for essential body functions
- RER = 70 x $kg^{0.75}$

MER = Maintenance energy requirement (kcal/day)
- Caloric energy requirement for individual
  - Life stage, BCS, activity, etc.
- RER x Life Stage Factor

What is the MER for a 15kg puppy (with a Life Stage Factor of 3)?

- 70 x $15^{0.75}$ = 533.5 x 3 = 1600 kcal/day

If the owner is feeding the puppy three times daily, how many cups of food (350 kcal/cup) should they give at each feeding?

- $\frac{1600\ kcal}{day} \times \frac{1\ cup}{350\ kcal} \times \frac{1\ day}{3\ servings} =$
- $\frac{1600\ \cancel{kcal} \times 1\ cup \times 1\ \cancel{day}}{1\ \cancel{day} \times 350\ \cancel{kcal} \times 3\ servings} = \frac{1600\ cups}{1050\ serving} =$ **1.5 cups per serving**

Table 1. Known life stages and corresponding factors used to estimate daily energy needs for dogs.

Neutered adult	=1.6 x RER
Intact adult	=1.8 x RER
Inactive/obese prone	=1.2-1.4 x RER
Weight loss	=1.0 x RER for ideal weight
Weight gain	=1.2-1.8 x RER for ideal weight
Active, working dogs	=2.0-5.0 x RER
Puppy 0-4 months	=3.0 x RER
Puppy 4 months to adult	= 2.0 x RER

Table 1: McCumin's (2021)

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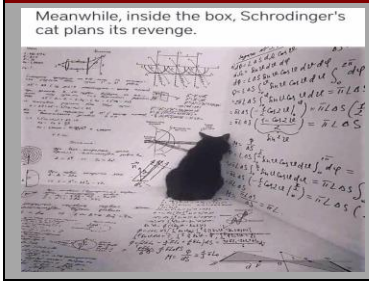
Anesthesia Math



- Tidal volume
- Reservoir bag size
- Oxygen flow rates

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Anesthesia math

- Tidal volume = the amount of air inhaled or exhaled with each breath
  - O2 consumption rate x kg
  - Typical consumption rate is 10-20 ml/kg/min
  - Using an oxygen consumption rate of 15 ml/kg/min, calculate the tidal volume for a 35 kg dog
    - 35 x 15 = 525 ml
- Reservoir bag size
  - Tidal volume x 5 ÷ 1000
  - 5-10 x tidal vol is typical to give enough buffer to keep bag inflated
  - For the patient above: 525 ml x 5 ÷ 1000 = 2.6 L → 3 L bag
- Oxygen flow rates
  - Only for rebreathing systems (non-rebreathing systems and longer tubes (CT) require higher O2 rate)
  - Tidal volume x 3 (offsets the dead space) ÷ 1000
  - For the patient above: 525 ml x 3 ÷ 1000 = 1.6 L/min

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You can do math!
(and honestly, you **must.**)

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