EDS 212: Day 1, Lecture 1

Course intro, algebra refresher

August 3rd, 2026

EDS 212 basics

* start on website, move here starting on algebra review

Welcome to EDS 212 - Essential Math in Environmental Data Science

- **Instructor:** Carmen Galaz García
- **Teaching assistant:** Cella Schnabel
- **Course hours:** 10am - 3:30pm PST
- **Location:** NCEAS 1st Floor Classroom

* add website and go over where everything is located in it (where to find slides)

About your instructor

Carmen Galaz García (she/her)

- Assistant Teaching Professor @ Bren

Before:

- Data Scienist @ NCEAS
- Ph.D. in Mathematics @ UCSB

Teaching & Research

- Python courses and Capstone Projects for Masters in Environmental Data Science (MEDS)
- Supporting math and data science across Bren!
- NCEAS/TNC collaboration for invasive iceplant mapping analyzing remotely sensed images

About your TA

* Figure out what's going on with rendering here (see GH issue).

About you!

image: Flaticon.com

Course description

- **Units:** 2
- **Grading:** Satisfactory/Unsatisfactory
- **Description:** Quantitative skills are critical when working with, understanding, analyzing and gleaning insights from environmental data. In the intensive EDS 212 course, students will refresh fundamental skills in math (algebra, uni- and multivariate functions, units and unit conversions), summary statistics and basic probability theory, derivative and differential equations, linear algebra, and reading, writing and evaluating logical operations.
- This is an **"offline course"**, your only one in MEDS. What it means is we'll be focusing on conceptual understanding and some pen-and-paper practice, instead of coding. Why? We want to make sure you *understand* some fundamental topics before jumping into *implementing*.

Let's take a look at the course syllabus together.

Topics overview

- **Day 1:** Course introduction & math basics refresher
- **Day 2:** Exponential functions; Limits & derivatives
- **Day 3:** Integration & ODEs; Vectors and matrices
- **Day 4:** Distributions & summary statistics; Basic probability theory,
- **Day 5:** Basic stats; Boolean algebra

Objectives (in general terms)

1. Shake off the math dust
2. Exercise core math skills needed to succeed in your Bren courses
3. Explore how valuable math is to environmental data science
4. Build a collaborative environment and get to know your cohort

Student expectations

We expect all students will:

- Support and encourage all classmates
- Be open to learning from each other
- Bring a collaborative attitude and communicate respectfully
- See opportunities to share kownledge as a chance to deepen understanding
- Complete all in-class exercises

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Logistics

- You are required to attend all sessions, unless there's a significant reason not to. Always communicate with your instructors.
- If you are feeling sick: stay home and take care of yourself! Please mask up if you are not feeling 100%.

Please fill out this survey

Or you can click on this link.

Math in Environmental Data Science

Why am I taking a math class?

or,

Why do I have to know math when a computer will do it for me?

A quantitative brain warm-up

MEDS students have diverse work & academic histories

This course (re)introduces math concepts and tools that:

- Focus on applications to environmental data science
- Are specifically relevant for MEDS projects, coursework
- Provide an entryway into building computational skills
- Refresh quantitative thinking skills generally
- Refresh essentials like units, conversions, notation, **language**

Share with the person next to you:

What has been your life or professional experience with math? Best friend ever, mortal enemy, or something in between?

How do you see math being relevant to solving environmental problems?

Math is a core tool in environmental data science

Math helps us investigate the world and communicate our findings

- Used by scientists to find evidence
- Can be used to quantify relations, trends, and changes
- Mathematical models can help us understand complex systems
- Must be used responsibly and with awareness of potential biases and limitations
- Helps us support arguments that can transform policy and actions
- At the center of tools like statistics, machine lerning, and image processing

We need to understand the math to make decisions and efficient implementations using it!

Math at Bren

In your classes:

- EDS 222: Statistics for Environmental Data Science
- EDS 230: Modeling Environmental Systems
- EDS 232: Machine Learning in Environmental Science

In Research

Ecology, modeling, economics, and more!

- Modeling the Impact of Decarbonization on Labor in California's Central Coast
- Quantifying Greenhouse Gas (GHG) Emissions Associated with Global Seafood Production
- Characterizing The Relationship Between Evapotranspiration and Groundwater Decline Across Arid Agricultural Regions

Today: Math brain warm up

- Algebra review
- Rules of exponents
- Units
- Functions
- Understanding graphs
- Linear functions

* Update this to include

- exponential function
- natural logarithm

Algebra review

Rules of algebra

You can get far with a few rules:

1. Follow order of operations (a.k.a. PEDMAS)
2. Never change an equation. Instead, rewrite them into more useful forms
3. Manipulate BOTH sides of an equation with the SAME PROCEDURE.

Always add/substract/multiply/divide by the same number on both sides. More generally, always apply the same function to both sides of the equation.

1. Order of operations (P-E-DM-AS)

P - Parentheses

E - Exponents

D/M - Division / multiplication

A/S - Addition / subtraction

1. Order of operations practice problems

✏️ Take a minute to solve these individually.

- Simplify $\frac{4-6}{2}(3+1) - \frac{1+2*4}{3}$

- Simplify $3x + 4(8x - 6x) - (2y - 5) + \frac{2x(1-3)}{2}$

- If we are given the values of $x = -3$ and $y = 2$, what would be the value of z?

$$z = 4 * (y - 4) + (x + 1)^2$$

1. Order of operations practice problems

💡 Let's see a solution!

$$\frac{4-6}{2}(3+1) - \frac{1+2*4}{3}$$

$$= \frac{-2}{2}(4) - \frac{1+8}{3}$$

$$= -1(4) - \frac{9}{3}$$

$$= -4 - 3$$

$$= -7$$

$$3x + 4(8x - 6x) - (2y - 5) + \frac{2x(1-3)}{2}$$

$$3x + 32x - 24x - 2y + 5 + \frac{2x - 6x}{2}$$

$$= 11x - 2y + 5 - \frac{4x}{2}$$

$$= 11x - 2y + 5 - 2x$$

$$= 9x - 2y + 5.$$

1. Order of operations practice problems

💡 Let's see a solution!

If we are given the values of $x = -3$ and $y = 2$, what would be the value of z?

$$z = 4 * (y - 4) + (x + 1)^2$$

$z = 4(2 - 4) + (-3 + 1)^2$

$= 4(-2) + (-2)^2$

$= -8 + 4$

$= \underline{-4}$.

*include slide with solution to the 3 exercises

1. Notation matters

Simplify the following: $6 \div 3(4+2)$ $= \frac{6}{3} \cdot (4+2) = 2 \cdot 6 = 12.$

What would be a harder-to-misinterpret way to write this?

$(6/3) \cdot (4+2).$

Chelsea Parlett-Pelleriti @ChelseaParlett · 26m ···

Instead of opaque PEMDAS "brain teasers" how about you break out a dang parenthesis or two and VALUE CLARITY OVER INSTANTANEOUS PRECEDENCE KNOWLEDGE

2 1 36

1. An important takeaway:

Being readable & hard to incorrectly interpret is often as important as being technically “correct”

When designing things, it’s important to **consider the different ways that users might misuse or misunderstand it** - then **build in safeguards** to help them use it correctly. **Clear communication** and **user-centered design** is critical in environmental data science.

2. Solving equations

Equations help us find unknown values that satisfy certain conditions.

Remember the rules:

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Always add/substract/multiply/divide by the same number on both sides. More generally, always apply the same function to both sides of the equation.

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Example

Prices are important in economics, but not always available for environmental goods.

How do we get prices if we know quantity?

$$Q = \frac{(400 - P)}{80} \qquad \text{Isolate P in terms of Q}$$

✏️ Take a minute to solve this individually.

2. Solving equations

💡 Let's see a solution!

Prices are important in economics, but not always available for environmental goods.

How do we get prices if we know quantity?

$$Q = \frac{(400 - P)}{80}$$ Isolate P in terms of Q

$$80Q = \cancel{80}\frac{(400 - P)}{\cancel{80}}$$

$$80Q = 400 - P$$

$$80Q + P = 400 \cancel{- P} \cancel{+ P}$$

$$80Q + P = 400$$

$$-\cancel{80Q} + \cancel{80Q} + P = 400 - 80Q$$

$$\rightarrow P = 400 - 80Q.$$

2. Solving equations

💡 Let's see a solution!

Prices are important in economics, but not always available for environmental goods.

How do we get prices if we know quantity?

$$
\begin{array}{rcll}
Q &=& \dfrac{(400 - P)}{80} & \qquad \text{Isolate P in terms of Q} \\[2ex]
80Q &=& \dfrac{(400 - P)\,\cancel{80}}{\cancel{80}} & \qquad \text{Multiply both sides by 80} \\[2ex]
80Q - 400 &=& \cancel{400} - \cancel{400} - P & \qquad \text{Subtract both sides by 400} \\
-1(80Q - 400) &=& -P(-1) & \qquad \text{Multiply both sides by -1} \\
400 - 80Q &=& P & \qquad \text{Flip terms for simplicity}
\end{array}
$$

It can be easy to make mistakes while doing algebra. Practice is key!

Solve all in terms of x

a. $3x + 2 = 10x - 12$

b. $4 - 3(2x + 1) = 8 - \frac{3x}{2}$

c. $3(x + 7a) - 5 = b + 2(c - 4x)$

✏️ Take a minute to solve these individually.

It can be easy to make mistakes while doing algebra. Practice is key!

💡 Let's see a solution!

Solve all in terms of x

a. $3x + 2 = 10x - 12$

$2 = 10x - 3x - 12$

$2 = 7x - 12$

$14 = 7x$

$\frac{14}{7} = x$

$\boxed{2 = x}$

b. $4 - 3(2x + 1) = 8 - \frac{3x}{2}$

$4 - 6x - 3 = \frac{16}{2} - \frac{3x}{2}$

$1 - 6x = \frac{16 - 3x}{2}$

$2 - 12x = 16 - 3x$

$-14 = 9x$

$\boxed{x = \frac{-14}{9}}$

It can be easy to make mistakes while doing algebra. Practice is key!

💡 Let's see a solution!

Solve all in terms of x

c. $3(x + 7a) - 5 = b + 2(c - 4x)$

$3x + 21a - 5 = b + 2c - 8x$

$+8x \qquad\qquad +8x$

$11x + 21a - 5 = b + 2c$

$+5 \qquad\qquad +5$

$11x + 21a = b + 2c + 5$

$-21a \qquad -21a$

$\frac{11x}{11} = \frac{b + 2c + 5 - 21a}{11}$

$x = \frac{5 + b + 2c - 21a}{11}$

Practice solutions

$$
\begin{aligned}
3x + 2 &= 10x - 12 \\
3x + 2 + 12 &= 10x - 12(+12) \\
3x - 3x + 14 &= 10x - 3x \\
14 &= 7x \\
x &= 2
\end{aligned}
$$

$$
\begin{aligned}
4 - 3(2x + 1) &= 8 - \frac{3x}{2} \\
4 - 3 - 6x &= 8 - \frac{3x}{2} \\
1 - 6x &= 8 - \frac{3x}{2} \\
2 - 12x &= 16 - 3x \\
-9x &= 14 \\
x &= \frac{-14}{9}
\end{aligned}
$$

Practice solutions

$$\begin{aligned}
3(x + 7a) - 5 &= b + 2(c - 4x) \\
3x + 21a - 5 &= b + 2c - 8x \\
11x + 21a - 5 &= b + 2c \\
11x &= 5 + b + 2c - 21a \\
x &= \frac{5 + b + 2c - 21a}{11}
\end{aligned}$$

Let's take a 5 minute break

Back at 11:20

image: Flaticon.com

Rules of exponents

Exponents make algebra more interesting!

Example

The expression x^3 means x multiplied by itself 3 times:

$$x^3 = x * x * x$$

More generally,

$$x^n = x \text{ to the power of } n.$$

Intuitively, the **exponent** n tells us how many times to multiply the **basis** x by itself:

$$x^n = \underbrace{x * x * \ldots * x}_{n \text{ times}} \qquad \underbrace{x \cdot x \cdot \ldots \cdot x}_{n \text{ times}},$$

But the exponent can be any (real) number, not only integers!

+ Check rendering of x^n.

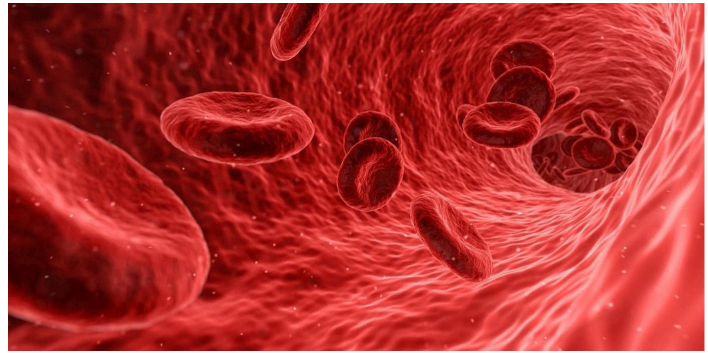
What are exponents good for?

They can describe really big numbers

Diameter of the Milky Way =
1,000,000,000,000,000,000,000 meters =

$$10^{21}\ \text{m}$$

And also really small numbers



Diameter of a human red blood cell =
0.0000000001 meters =

0.

$$10^{-10}\ \text{m}$$

This way, we can use exponents to describe exponential growth and decay. Many environmental variables behave in this way.

Rules and properties of exponents (1)

1. Product rule: $x^a \cdot x^b = x^{a+b}$

✏️

2. Quotient rule: $\frac{x^a}{x^b} = x^{a-b}, \quad x \neq 0.$

3. Any non-negative x to the power of 0 equals 1: $x^0 = 1, \quad x \neq 0$

4. Negative exponent means divide: $x^{-a} = \frac{1}{x^a}, \quad x \neq 0$

5. Fractional exponent means take the n-th root: $x^{\frac{1}{n}} = \sqrt[n]{x}.$

Rules and properties of exponents (2)

6. Power of a power means multiply the exponents: $(x^a)^b = x^{ab}$

✏️

7. Exponents get distributed over products: $(xy)^a = x^a y^a$

8. And exponents get distributed over divisions: $\left(\frac{x}{y}\right)^a = \frac{x^a}{y^a}$.

9. If a is the n-th root of x, then a to the n equals x:

$$a = \sqrt[n]{x} \Rightarrow a^n = x.$$

Rules and properties of exponents (1)

1. Product rule: $x^a * x^b = x^{a+b}$

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Rules and properties of exponents

Rule	**Expression**
Product Rule	$x^a \cdot x^b = x^{a+b}$
Quotient Rule	$\frac{x^a}{x^b} = x^{a-b}, \quad x \neq 0$
Zero Exponent	$x^0 = 1, \quad x \neq 0$
Negative Exponent	$x^{-a} = \frac{1}{x^a}, \quad x \neq 0$
Fractional Exponent	$x^{\frac{1}{n}} = \sqrt[n]{x}$
Power of a Power	$(x^a)^b = x^{ab}$
Power of a Product	$(xy)^a = x^a y^a$
Power of a Quotient	$\left(\frac{x}{y}\right)^a = \frac{x^a}{y^a}$
n-th Root Definition	$a = \sqrt[n]{x} \quad \Rightarrow \quad a^n = x$

Exponents practice

✏️ Simplify the following.

a. $\frac{6^5}{6^3} = 6^{5-3} = 6^2 = 36$

$= 6^5 \cdot 6^{-3} = 36$

b. $(x^2y)^4 = x^{2\cdot 4} \cdot y^4 = x^8 \cdot y^4.$

c. $\frac{x^5y^6}{xy^2} = x^{5-1} \cdot y^{6-2} = x^4 \cdot y^4 = (xy)^4.$

d. $\frac{24x^6}{12x^{-8}} = 2 \cdot x^{6-(-8)} = 2 \cdot x^{6+8}$

$= 2x^{14}$

Rule	Expression
Product Rule	$x^a \cdot x^b = x^{a+b}$
Quotient Rule	$\frac{x^a}{x^b} = x^{a-b}, \quad x \neq 0$
Zero Exponent	$x^0 = 1, \quad x \neq 0$
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Power of a Power	$(x^a)^b = x^{ab}$
Power of a Product	$(xy)^a = x^a y^a$
Power of a Quotient	$\left(\frac{x}{y}\right)^a = \frac{x^a}{y^a}$
n-th Root Definition	$a = \sqrt[n]{x} \quad \Rightarrow \quad a^n = x$

Exponents practice

✏️ Let's see a solution.

a. $\frac{6^5}{6^3} = 6^{5-3} = 6^2$

Fix

b. $(x^2y)^4 = (x^2)^4 * y^2 = x^8y^2$

c. $\frac{x^5y^6}{xy^2} = \frac{x^5}{x} * \frac{y^6}{y^2} = x^{5-1} * y^{6-2} = x^4y^4 = (xy)^4$

d. $\frac{24x^6}{12x^{-8}} = 2x^6x^{(-(-8))} = 2x^6x^8 = 2x^{6+8} = 2x^{14}$

Multiplying expressions (FOIL)

First, **O**utside, **I**nside, **L**ast

Example:

$$(2x + 5)(x - 3)$$

✏️ Expand this expression.

$$2x(x-3) + 5(x-3)$$

$$= 2x \cdot x - 2x \cdot 3 + 5 \cdot x - 15$$

$$= 2x^2 \underline{- 6x + 5x} - 15 = \boxed{2x^2 - x - 15.}$$

Multiplying expressions (FOIL)

First, **O**utside, **I**nside, **L**ast

Example:

$$(2x + 5)(x - 3)$$

✏️ Let’s see a solution.

$$= (2x \times x)(2x \times -3)(5 \times x)(5 \times -3)$$

$$= 2x^2 - 6x + 5x - 15$$

Polynomials describe more complex relationships through exponents

A polynomial is a function of the form:

$$a_n x^n + a_{n-1} x^{n-1} + \ldots + a_1 x + a_0 \quad x^0$$

- x is the **variable**
- a_i are **constants** (fixed numbers) that are called the **coefficients** of the polynomial
- each $a_i x^i$ is called a **term** of the polynomial,
- n is called the **degree** of the polynomial, this is the largest exponent in the polynomial.

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- each $a_i x^i$ is called a **term** of the polynomial,
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Example:

- $x^5 + x^2 - 1$ is a polynomial of degree five with three terms.
- Linear functions like $mx^1 + c$ where m and c are constants are polynomials of degree 1!

Polynomials often represent real world data better than a linear function.

Units

UNITS. UNITS. UNITS.

Think about these statements, which all contain the same *value* of 4:

- There are four in the refrigerator.
- There are four **burritos** in the refrigerator.
- There are four **roaches** in the refrigerator.
- There are four **million dollars** in the refrigerator.

UNITS. UNITS. UNITS.

Think about this sign at New Cuyama. Anything odd here?

Units are critical in environmental data science

We cannot responsibly work with data without knowing the units of **each variable we're working with**.

That means we need to always **familiarize ourselves with metadata**, carefully **check units and any unit conversions**, and understand **how units combine into the units of a dependent variable**.

Dimensional analysis (unit conversions)

In dimensional analysis, we multiply initial units by a sequence of **unit conversion factors** to arrive at the final desired units.

Example: How many centimiters are there in 6 inches?

✏️ Let's solve this together.

We know 1 in = 2.54 cm, This gives two conversion factors

$$\frac{2.54\,\text{cm}}{1\,\text{in}} \quad \text{and} \quad \frac{1\,\text{in}}{2.54\,\text{cm}}$$

We multiply by the appropriate conversion factor:

$$6\,\text{in} = 6\,\text{in} \cdot \frac{2.54\,\text{cm}}{1\,\text{in}} = 6 \cdot \frac{2.54}{1}\,\cancel{\text{in}}\,\frac{\text{cm}}{\cancel{\text{in}}}$$

$$= 15.24\,\text{cm}$$

Dimensional analysis (unit conversions)

In dimensional analysis, we multiply initial units by a sequence of **unit conversion factors** to arrive at the final desired units.

Example: How many centimiters are there in 6 inches?

We know: 1 inch = 2.54 cm. This gives us two unit conversion factors:

$$\frac{2.54\ \text{cm}}{1\ \text{in}} \text{ and } \frac{1\ \text{in}}{2.54\ \text{cm}}.$$

Important: the fraction the numerator and denominator represent the same quantity.

Then we multiply by the *appropriate* conversion factor and simplify:

Dimensional analysis (unit conversions)

Example. Convert $100\,\frac{g}{cm^3}$ into units of $\frac{kg}{in^3}$, given that 1 cm^3 = 0.061 in^3.

✏️ Let's solve this together.

One conversion factor : $\dfrac{1\text{ kg}}{1000\text{ g}}$

Second : $\dfrac{1\text{ cm}^3}{0.061\text{ in}^3}$

Multiply and simplify :

$$100\,\frac{g}{cm^3} = 100\,\frac{g}{cm^3}\cdot\frac{1\text{ cm}^3}{0.061\text{ in}^3}\cdot\frac{1\text{ kg}}{1000\text{ g}}$$

$$= 100\cdot\frac{1}{0.061}\cdot\frac{1}{1000}\cdot\frac{\cancel{g}}{\cancel{cm^3}}\cdot\frac{\cancel{cm^3}}{in^3}\cdot\frac{kg}{\cancel{g}}$$

$$= 1.639\,\frac{kg}{in^3}.$$

Dimensional analysis (unit conversions)

Example. Convert $100 \frac{g}{cm^3}$ into units of $\frac{kg}{in^3}$, given that 1 cm^3 = 0.061 in^3.

We need one unit conversion factor for g: $\frac{1 \text{ kg}}{1000 \text{ g}}$.

And another one for cm^3: $\frac{1 \text{ cm}^3}{0.061 \text{in}^3}$.

Then we multiply by the conversion factors and simplify

$$
\begin{aligned}
100 \frac{\text{g}}{\text{cm}^3} &= 100 \frac{\text{g}}{\text{cm}^3} \cdot \frac{1 \text{ cm}^3}{0.061 \text{ in}^3} \cdot \frac{1 \text{ kg}}{1000 \text{ g}} \\
&= 100 \frac{1}{0.061} \frac{1}{1000} \cdot \frac{\text{g}}{\text{cm}^3} \frac{\text{cm}^3}{\text{in}^3} \frac{\text{kg}}{\text{g}} \\
&= \frac{1}{0.61} \cdot \frac{\cancel{\text{g}}}{\cancel{\text{cm}^3}} \frac{\cancel{\text{cm}^3}}{\text{in}^3} \frac{\text{kg}}{\cancel{\text{g}}} \\
&= 1.639 \frac{kg}{in^3}
\end{aligned}
$$

Unit conversion practice

1. Convert $8.1\frac{km}{s}$ to miles per hour, given that 1 km = 0.621 miles.

$$\frac{1\,hr}{3600\,s} \qquad \frac{1\,km}{0.621\,mi}$$

$$8.1\,\frac{km}{s}\cdot\frac{3600\,s}{1\,hr}\cdot\frac{0.621\,mi}{km} \Rightarrow 8.1\times 3600\times 0.621\cdot\frac{\cancel{km}}{\cancel{s}}\cdot\frac{\cancel{s}}{hr}\cdot\frac{mi}{\cancel{km}}$$

2. You are combining information from multiple sources to estimate the total annual oil spilled in a watershed, reported by different companies. The following are reported for the year:

- **Company A:** 14.6 barrels spilled (with 9.3 barrels recovered)
- **Company B:** 692 liters spilled (94% recovered)
- **Company C:** 18.1 gallons spilled (0% recovered)

What is the total *unrecovered* amount of oil spilled into the watershed that year, in barrels. Use ~~R & Google~~ here for calculations.

a calculator

* Update to include equivalence for barrels, gallons, and liters.

Lunch break!

See you at 1pm !

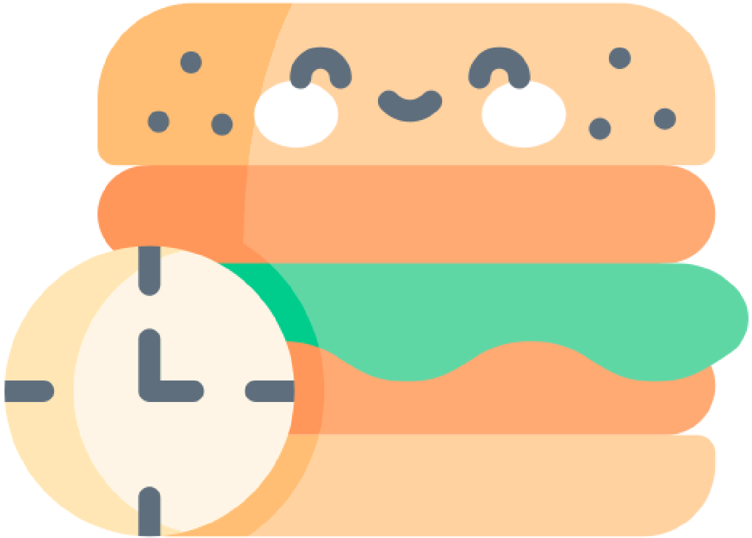

image: Flaticon.com