Fitness Math:
Math for the Fitness Professional

Thank you for choosing Fitness Math. In this course, you'll review and practice the math skills required for a career as an ACE-Certified fitness professional.

You'll review and practice:

- Using common calculations to evaluate fitness levels
- Designing exercise programs with appropriate workloads and intensities
- Applying basic nutrition data

Using math with confidence has clear benefits, no matter where your fitness career takes you.

Let's get started!

Fitness Math:
Common Abbreviations

For your reference, common fitness abbreviations used in this course and their meanings are provided.

In addition, abbreviations for standard and metric units are used throughout the course. They'll be defined as they're introduced.

%1-RM	% of 1-Rep Max
BMI	Body Mass Index
BW	Body Weight
DBF%	Desired Body Fat %
FW	Fat Weight
HRR	Heart Rate Reserve
Kcals	Kilocalories; also called calories
LW	Lean Weight
METs	Metabolic Equivalents
MHR	Maximal Heart Rate
RHR	Resting Heart Rate
THR	Target Heart Rate
VO2	Oxygen Consumption
VO2max	Maximal Oxygen Consumption
WHR	Waist- to- Hip Ratio

Fitness Math: What Will You Learn?

1. How to convert percentages to decimals
2. Units of measure and conversions:
   - -Standard and Metric
   - -Mass, Distance and Volume
3. Applying common formulas used in fitness assessments:
   Body Mass Index (BMI), Body composition, waist-to-hip ratio (WHR)
4. How to perform calculations for exercise program design:
   -Target Heart Rate (THR), Max Heart Rate (MHR),
   Heart Rate reserve (HRR), maximal oxygen consumption (VO_2max), energy expenditure, % 1-rep max
4. Nutrition:
   -Caloric values of food based on macronutrient content, creating caloric deficits for weight loss

Note: Formulae and charts refer specifically to material covered in The American Council on Exercise (ACE) Personal Trainer Manual 4th edition.

When Do Fitness Professionals Use Math?

As a fitness professional, you'll use math throughout your career. A few examples are listed below:

- **ACE certification exam** —This course will help you prepare for some of the math problems you may see on the exam. *A basic 4-function calculator will be provided by the exam proctor for you to use on the ACE certification exam. Candidates are **not** allowed to bring their own calculators.*
- **Initial fitness assessment** — Taking measurements, calculating BMI, body fat and *lean weight %, waist-to-hip ratio (WHR).
- **Client re-assessment** —Comparing initial numbers to follow-up results measures the success of the client's exercise program.

**Note: Lean weight is also referred to as lean body mass or lean body weight. In this course, we'll use the term lean weight (LW).*

When Do Fitness Professionals Use Math?

- **Determining workload, intensity and duration** —Identifying target heart rate, workload, and time required to burn desired number of calories.

- **Nutrition support** — Helping clients learn to make sense out of nutrition labels and calculate caloric value of food.

A working knowledge of math is vital to your success as a fitness professional.

Nutrition Facts

Serving Size 1 potato (148g/5.3oz)

Amount Per Serving	
Calories 100	Calories from Fat 0
	% Daily Value*
Total Fat 0g	**0%**
Saturated Fat 0g	**0%**
Cholesterol 0mg	**0%**
Sodium 0mg	**0%**
Potassium 720mg	**21%**
Total Carbohydrate 26g	**9%**
Dietary Fiber 3g	**12%**
Sugars 3g	
Protein 4g	

Vitamin A 0%	• Vitamin C 45%
Calcium 2%	• Iron 6%
Thiamin 8%	• Riboflavin 2%
Niacin 8%	• Vitamin B_6 10%
Folate 6%	• Phosphorous 6%
Zinc 2%	• Magnesium 6%

*Percent Daily Values are based on a 2,000 calorie diet.

Converting % to Decimals

When will you use this skill?
When putting a percentage into a formula, such as determining target heart rate or using body composition data to calculate lean vs. fat tissue.

Examples:

- Calculating percent of predicted maximum heart rate
- Calculating ideal weight for a client who’s 32% fat
- Determining % fat for a serving of food that is 350 calories and contains 12g of fat.

Converting % to Decimals

To convert a percentage to a decimal, replace the percent sign with a decimal point and move the decimal point two places over to the left.

Example:

75% of your Maximal Heart Rate (MHR) is written as .75 when used in the formula to find your Target Heart Rate (THR).

75% → .75

To convert a decimal to a percentage, do the opposite and replace the decimal point with a percent sign:

.65 → 65%

Rounding Numbers

As you complete equations, you'll often need to round to the nearest *whole number* - a number without any digits to the right of the decimal point.

Example:

After converting Sarah's lean weight from pounds to kilograms, you get the number 42.348. Rather than write out all numbers after the decimal point, round to the nearest *whole number*. In this case 42.348 should be *rounded down* to 42.

When a number is less than (<) 5, round *down*.

When a number is equal or greater than (≥) 5, round *up*.

More Examples:

162.6 → 163	83.2 → 83
172.72 → 173	148.3 → 148
190.5 → 191	221.4 → 221

Fractions

A fraction is part of a whole. It includes the numerator (number on top of the fraction) and the denominator (number on the bottom of the fraction).

$$\frac{1}{4}$$

Numerator

Denominator

Example:

One pizza slice is a part of the whole pizza. You've ordered a medium pizza with 8 total slices. You eat 2 slices. What fraction of the pizza did you just eat?

A fraction can be reduced if the numerator and denominator are evenly divisible by the same number. Divide both the numerator and denominator by the same number. The resulting numerator and denominator create The reduced fraction.

$$\frac{2}{8} \div 2 = \frac{1}{4}$$

You've eaten 2/8 or ¼ of the pizza.

Converting Fractions to Decimals

Sometimes converting a fraction to a decimal is required to complete a formula. To convert a fraction, divide the top number (numerator) by the bottom number (denominator).

Example: When you want to find out how many calories are in 3/4 of a serving, convert the fraction into a decimal.

3 divided by 4 = 0.75 then multiply times the # of calories in the serving

```
             .75
3/4  →  4 ) 3.00
            .28
             .20
             .20
               0
```

In this example, if the serving has 450 calories, multiply 450 X 0.75 = 337.5; rounding up = 338 calories for the 3/4 serving.

Converting Fractions to Decimals

Some commonly used fractions & corresponding percentages are listed below:

Fraction	Action	Decimal	Percent
1/8	1 divided by 8	0.125	13%
1/5	1 divided by 5	0.2	20%
¼	1 divided by 4	0.25	25
1/3	1 divided by 3	0.33	33%
3/8	3 divided by 8	0.375	38%
2/5	2 divided by 5	0.4	40%
½	1 divided by 2	0.5	50%
2/3	2 divided by 3	0.66	66%
¾	3 divided by 4	0.75	75%
4/5	4 divided by 5	0.80	80%
7/8	7 divided by 8	0.875	88%

Multiplying with Decimals

Multiplying with decimals is most commonly used to determine target heart rates.

Example: Calculate 50% of Joe's MHR of 180 beats per minute (bpm).

First convert the percentage to a decimal (50% = 0.50) Leave out the decimal point for now.

1. Complete the multiplication to find the *product. 50 x 180 bpm= 9000*
2. Once you're done, simply add back the two decimal places. 90.00, or 90 bpm

Let's walk through this calculation together on the next slide.

Multiplying with Decimals

To find 50% of a MHR of 180, use the following steps:

1. Convert the percent to a decimal. 50% → .50

2. Remove the decimal before you multiply. 180 x 50

180
x50
000 (Multiply 0 x 180)
9000 (Multiply 5 x 180. Be sure to move to the left one place.)
9000 (Add the first and second lines)

3. Put the two decimal places back into 9000, which gives you 90.00, or 90 bpm.

Multiplying with Decimals

Sometimes you'll need to multiply a decimal with two numerals. Here's how to find 85% of a MHR of 175 bpm:

Convert 85% to a decimal → 0.85; then multiply the MHR of 175 bpm by 0.85

```
  175          175
x .85    →    x 85
               875  (5 x 175)
            +14000  (8 x 175)
             14875  = 148.75 = 149 bpm
                    Insert decimal  →  Round number
```

Dividing with Decimals

Math is used to set specific fitness goals. Effective goals are:

S.M.A.R.T.

Specific, **M**easurable, **A**ttainable, **R**elevant and **T**ime-bound.

The more specific the goal, the more precise you can be when designing a program to achieve that goal.

Establishing specific goals often requires Dividing by a percentage, which can be done after converting the percentage to a decimal.

Dividing with Decimals

To determine a client's body weight at a desired % fat, you'll need to divide with a decimal.

Example: Meghan weighs 165 lbs.

- After measuring her skinfolds, you use the Jackson/Pollock equation to calculate her body composition. (ACE Personal Trainer Manual 4th edition, ch. 8 pg. 178-184).
- Her body fat is 25% - which means that 75% of her weight is *lean weight*.

On the next slide, let's help Meghan set a body weight goal that correlates with lowering her body fat to 20%.

Dividing with Decimals

Using Meghan's data, let's solve this problem using the following steps:

1. Determine Meghan's lean weight. We know that 25% of her total body weight (165 lbs.) is fat weight, so the remaining 75% is lean weight.
2. Convert 75% to .75 and multiply by Meghan's total body weight to determine her *current* lean weight:

   Lean weight: 165 X 0.75 = 123.75 lbs (round up to124 lbs.)

3. Divide Meghan's *current* lean weight (124 lbs.) by her *desired* lean weight percentage (80%, or 0.80).

Note: Meghan wants to reach a fat weight of 20%.This requires an increase in her lean weight from 75% to 80%. Her lean weight % increases as her body fat % decreases.

Dividing with Decimals - Illustration

In this example, 0.80 is the *dividend* and 124 is the *divisor*.

```
                     155.00   Meghan should weigh 155 lbs when she
124/.80  →  80.|12400         achieves 20% body fat.
             - 80
               440 (add 0 to 124 to continue dividing)
             - 400
                400 (add 0 to 1240 to continue dividing)
              - 400
                  0 (there is nothing left to divide)
```

The result is Meghan's desired body weight at 20% fat: 155 lbs., a weight loss of 10 lbs. This assumes that any weight lost is fat tissue.

Note: Dividing with decimals is similar to multiplying—remove the decimal to do the math then add it back to the proper place when the problem is complete.

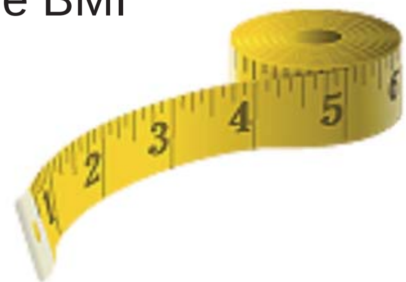
Units of Measure

Units of measure are used to identify the specific amount of a particular item.

As a fitness professional, you'll do a great deal of measuring. At times, you'll need to convert units of measure from traditional – or *standard* – units to *metric* units.

For example:

- Converting height from feet and inches to meters.
- Converting weight from pounds to kilograms for the BMI formula or calories burned during an exercise.



Units of Measure: Standard Units

Standard units of measure commonly used in the US include:

Mass (weight)	Distance (height)	Volume
Ounce (oz)	Inch	Cup
Pound (lb)	Foot	Pint
Ton	Yard	Quart
	Mile	Gallon

Many equations used by fitness professionals are based on the metric system and require the ability to convert measurements from standard to metric units.

Units of Measure: Metric System

The following are the base metric units of measure for mass, distance and volume—the 3 most common units of measure used by fitness professionals

Mass	Distance (height)	Volume
Grams (g)	Centimeters (cm)	Milliliters (mL)
Kilograms (kg)	Meters (m)	Liters (L)
	Kilometers (Km)	

Units of Measure: Metric System

The metric system can be confusing at first, but once you understand the prefixes, it's easier. Keep in mind that metric measurements are based on units of 10. The prefix tells you the value of the base unit.

Prefix	Value
Milli (thousandth)	0.001 (1/1000) One-thousandth
Centi (hundred)	0.01 (1/100) One-hundredth
Kilo (thousand)	1000 One-thousand

Metric System: Units of Measure

To convert a number from one metric unit of measure to another simply multiply or divide by a factor of 10 (10, 100, 1000). The base number stays the same, but the decimal point location changes.

Mass	Distance (height)	Volume
1 gram (g) = 1000 milligrams (mg) and/or 0.001 kilograms (kg)	1 centimeter (cm) = 0.01 meters (m) 0.0001 kilometers (km)	1 milliliter (mL) = 0.001 Liters (L)
1 kg = 1000 g and/or 100,000 mg	1 m = 100 cm 0.001 km	1 L = 1000ml
	1 km = 10,000 cm 1000 m	

Converting Units of Measure: Distance

The most common distance conversion you'll do is converting height from feet and inches to meters when calculating BMI.

Metric	Standard
1 meter (m)	3.3 feet
1 meter (m)	39.6 inches
1 centimeter (cm)	.4 inches

To convert cm to m, move the decimal point 2 places to the left:

185.cm = 1.85 meters

Converting Units of Measure: Distance

Common conversions involve distance or height. Some formulas, such as Body Mass Index (BMI), require converting height into feet and inches to meters. Listed below are distances in standard units of Measure (inch, foot, yard) and their metric equivalents.

Standard → Metric

** The numbers in red are used most frequently for conversions*

1 inch=	**1 foot =**	**1 centimeter =**	**1 meter =**
2.54cm	12 inches	0.393 inches	39.3 inches
0.083 feet	30.5cm	0.032 feet	3.3 feet
0.033m	0.31m	0.01m	100cm

Note: The decimal point moves two places right-to-left
to convert the units from centimeters (the smaller unit) to meters (the larger unit).

Converting Units of Measure: Distance

In case you have a client who is interested in training for a running race, here are some other distances and the conversions between Metric and Standard units:

Standard → Metric

** The numbers in red are used most frequently for conversions*

1 yard=	1 meter =	1 kilometer =	1 mile =
36 inches	39.37 inches	39,370 inches	63,360 inches
0.91 meters	1 meter	1000 meters	1609.35 meters
0.0009 km	0.001km	1 km	1.61km
0.00056 miles	0.0006miles	0.62 miles	1760 yards

Converting Standard Units to Metric Units: Distance

The easiest way to convert height from standard to metric units is to convert height to inches and multiply by 2.54 cm/inch. You can then convert centimeters to meters.

1) Convert the height from feet and inches into total inches (12 inches/foot).
2) Multiply the number of inches by 2.54 cm/inch to find height in cm.
3) Move the decimal point 2 places to the left to find height in meters

Examples:

	Step 1		Step 2	Step 3
5' 4" →	convert to inches →	64" →	64 x 2.54cm = 162.6cm	= 1.63m
5' 8" →	convert to inches →	68" →	68 x 2.54cm = 172.72cm	= 1.73m
6' 3" →	convert to inches →	75" →	75 x 2.54cm = 190.5cm	= 1.91m

Converting Units of Measure: Mass

Another typical conversion is for units of mass, or weight. Many common equations require weight in kilograms, but you typically have weight data in pounds (lbs). You'll need to convert from pounds (lbs.) to kilograms (kg). Common units of weight and their conversions are listed below:

* The numbers in red are used most frequently for conversions

1 ounce (oz) =	1 pound (lb) =	1 gram (g) =	1 Kilogram (kg) =
0.06 lbs	16 oz	0.035 oz	35.2 oz
28.35 g	453.6 g	0.002 lbs.	2.2 lbs
0.028 Kg	0.45 Kg	0.001 Kg	1000 g

Illustration: Converting Pounds (lbs.) to Kilograms

The process of converting lbs. to kg requires a simple math problem—take the weight in lbs and multiply by 0.45 (since a lb is 0.45 of a kg)

For example:

To convert 115 lbs into kg → 115 x 0.45 = 52 kg (51.75)

To convert 140 lbs into kg → 140 x 0.45 = 63 kg

To convert 183 lbs into kg → 183 x 0.45 = 82 kg (82.35)

Illustration:
Converting Pounds to Kilograms

Another method of converting pounds to kilograms is to divide the pounds by 2.2.

Examples:

115/2.2 = 52 kg (52.27)

140/2.2 = 64 kg (63.6)

183/2.2 = 83 kg (83.2)

Converting Units of Measure: Volume

You'll use volume to measure oxygen consumption ($V0_2$) - ml of oxygen per kg of body weight per minute during exercise.

Once you know $V0_2$, you can estimate caloric expenditure during a workout or make recommendations for fluid intake.

* The numbers in red are used most frequently for conversions

1 fluid ounce (fl. oz.) =	1 quart =	1 gallon =	1 milliliter (mL) =	1 Liter (L) =
0.008 gallons	32 fl. oz.	128 fl. oz.	0.03 fl. oz.	33.3 fl .oz.
29.57 mL	946 mL	3790mL	0.0003 gallons	0.26 gallons
0.029 L	0.946 L	3.79L	0.001L	1000mL

Converting Units of Measure: Volume

Staying well hydrated is a key component of a well-rounded exercise program. The ACSM guidelines for hydration during exercise are written in both standard and metric units.

Fluid Intake Recommendations During Exercise:

2 hrs Prior to Exercise	During: Every 10-20 minutes	Following Exercise
500-600 mL	200-300 mL	450-675 mL/for every 0.5 kg body weight lost
17-20 fl. oz.	7-10 fl. oz.	16-24 fl. oz. for every lb of body weight lost

Using Math for Client Assessment

Body Mass Index (BMI)

Waist-to-Hip Ratio (WHR)

Body Composition: % of lean tissue

Finding a Body Mass Index (BMI)

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height}^2\text{(meters)}}$$

BMI is widely used in research, health care, and fitness settings to identify and track overweight and obesity, but it’s not appropriate for pregnant or very muscular individuals. BMI is an effective, non-invasive tool for tracking progress for extremely overweight or obese clients.

- A healthy BMI=18-24.9 ; overweight =25 -29.9; obese = 30+

Calculating BMI requires converting height and weight from standard to metric units of measure.

Finding BMI
A Sample Problem

Carlos: 5’ 4”; 170 pounds. Find his BMI:

1) Convert lbs to kg: 170 x 0.45 = 76.5 → 77 kg
2) Convert height to meters: 5’ 4” → 64” x 2.54 = 163 (162.56) → 1.63 m
3) Find the square of the height: 1.63^2 → 1.63 X 1.63 = 2.66
4) Divide the weight by the product of the height squared:
   77/2.66 = 28.9;

BMI = 28.9

Based on his BMI measurement, Carlos would be considered *overweight* .

Refer to ACE’s Personal Trainer Manual 4th Edition page 185-186
View tables 8-7, 8-8 and 8-9

Application of the BMI

The client in this example, Carlos, has a history of being sedentary and is overweight. For an overweight or obese client, undergoing a skinfold measurement can be awkward and embarrassing – and it's considered less accurate for the obese population.

Instead, use *BMI* during initial and follow-up assessments to establish a baseline and to measure progress – at 3 month intervals.

For Carlos, progress may be demonstrated when he drops from a BMI of 28.9 to 24. After the initial improvement, he may be more comfortable with skinfold measurements.

Waist to Hip Ratio (WHR)

Waist-to-hip ratio measures the circumference of the waist relative to the hips and is also used as a marker of risk for metabolic and cardiovascular disease. As a client loses weight, changes in WHR can demonstrate measurable progress.

$$\text{WHR} = \frac{\text{Waist}}{\text{Hip}}$$

To calculate waist-to-hip ratio:

- Divide waist circumference by hip circumference
  - This measurement is a ratio so it can be done in either standard or metric units of measure

    If the waist is 28" and the hips are 32" then 28/32 = 0.875

    If the waist is 71cm and the hips are 81cm then 71/81 = 0.875

  No matter what the units of measure, the ratio remains the same.

Refer to ACE's Personal Trainer Manual 4th Edition page 187-188

View tables 8-10, 8-11, 8-12

Body Composition: The Jackson/Pollock Method

Clients often want to lose weight or alter their body compositions – increasing muscle and/or losing fat.

- The Jackson/Pollock method is a simple and widely-used skinfold caliper method.
- The method requires measuring the subcutaneous fat at 3 different sites, 3 times each :
  - **Men: chest, abdomen, thigh**
  - **Women: triceps, suprailiac crest, thigh**
- These measurements are averaged, added together and compared against standards.

Refer to ACE's Personal Trainer Manual 4th Edition pages 178-184

Body Composition:
The Jackson/Pollock Method

Steps to Jackson/Pollock Method:

1) Use skinfold calipers to find the 3 measurements at each site.
2) Add the measurements together for each site.
3) Divide by 3 to find the average skinfold thickness for that site.
4) Add together the average of the 3 measured sites.
5) Compare this value to the standardized charts for body fat%.

Refer to table 8-3 pg. 181 for Men and table 8-4 pg. 182 for women in the Personal Trainer 4th Edition Manual

Example:
The Jackson/Pollock Method

Review this example for using the Jackson/Pollock method:

Female, age 34; 3 measurements for each site:

Triceps—17 + 19 + 19 = 55/3 = **18** (18.3)

Suprailiac—8 + 6 + 8 = 22/3 = **7** (7.3)

Thigh—24 + 25 + 25 = 74/3 = **25** (24.6)

Add the averages together and refer to table 8-3 pg. 181 for Men and table 8-4 pg. 182 for women to find specific body fat % based on the client's gender, age, and skinfold measurements.

18 + **7** + **25** = **50** → **21.3%** body fat

Example:
The Jackson/Pollock Method

Review this example for using the Jackson/Pollock method:

Male, age 46; 3 measurements for each site:

Chest— 18 + 19 + 19 = 56/3 = **19** (18.6)

Abdominal— 35 + 36 + 37 = 108/3 = **36**

Thigh— 22 + 24 + 24 = 70/3 = **23** (23.3

Again, add the averages together and refer to Table 8.3 pg. 181 in the 4th ed. to find specific body-fat % based on the client's gender, age and measurements.

19 + **36** + **23** = **78** → **24.6%** body fat

Body Composition:
Determine Desired Body Weight (DBW)

Almost every fitness client wants to tone up and lose weight. Once you've determined your client's body composition, you can use the data to establish specific goals for body weight and lean weight.

There are 4 steps for using current body weight and current body fat percentage to determine an ideal weight at a desired percentage of body fat (DBF).

The formula for determining desired body weight (DBW) at a certain percentage of body fat is:

DBW = Lean Weight (LW)/(1-DBF%)

Let's walk through this calculation on the next few slides.

Body Composition:
Determine Desired Body Weight (DBW)

Desired Body Weight = Lean Weight/(1-Desired Body Fat%)

1. Determine lean weight (LW) by subtracting the body fat percentage from 100%:
   100% - Fat% = Lean Weight (LW)%

2. Calculate Lean Weight (LW). Multiply current body weight by the percentage of Lean Weight (LW):
   Body weight X LW% = Lean Body Weight (LW)

3. Subtract desired percentage of body fat (desired fat %) from 100 to find the desired percentage of lean weight (Desired LW%):
   100% - Desired fat% = Desired LW%

4. Divide *current* Lean Weight (LW) by desired percentage of Lean Weight (LW %) to determine client weight at desired body fat percentage goal:
   LW/Desired LW% = DBW @ the desired level of LW

Refer to ACE's Personal Trainer Manual 4th Edition Table 8-5 page 184 for Body fat % categories

DBW From a Goal of Desired Body Fat%

Let's apply this formula to a client example.

Your client is Sharon, a 34 year old woman. She weighs 130 lbs. and has a body fat of 21.3%. Her goal is to achieve a body fat of 18%. Find her goal weight.

1. Find the % of LW: 100% – 21.3% = 78.7% LW
2. Find the specific LW: 130 lbs. X .787 = 102.3 lbs. LW
3. Desired LW% = 100% - Desired fat% = 100%-18% = 82%
4. Divide LW by desired lean weight % 102 lbs./82%

   → 102/.82 = 124.4 lbs.

Sharon's goal weight is 124 lbs. Her exercise program should focus on safe, effective ways to lose 6 lbs of BW and 3% body fat.

DBW From a Goal of Desired Body Fat%

Let's work through another example. Your client is Wayne, a 46 year old male, who weighs 208 lbs at a body fat % of 24.6%. Wayne's body fat goal is 20%. What is his goal weight?

1. 100-24.6 = 75.4% LW
2. 208 X .754 = 157 lbs. (156.8) LW
3. Desired body fat % (client goal) = 20%;
   Desired LW % = 100% - 20% = 80%
4. 157 lbs./80% → 157/.80 = 196 lbs.

At Wayne's goal of 20% body fat, his BW should be 196 lbs., assuming he maintains his lean weight. His exercise program should focus on safe, effective ways to lose 12 lbs. of BW which represents about 5% body fat.

Math for Exercise Program Design

Using math is critical for determining the appropriate intensity for a client's exercise program, especially when designing a program for cardiovascular training.

Clients – especially those with pre-existing health conditions – who exercise at too high an intensity risk serious injury.

Clients who exercise at too low an intensity won't achieve their goals. Use math when designing programs to ensure the best possible outcomes. Results provide motivation, improve self-efficacy, and engage clients in their fitness programs.

Math for Exercise Program Design

This section will address how to complete the following equations:

- Heart Rate (HR) Training Zones - Max HR and Target HR
- Heart Rate Reserve - Karvonen Formula
- VO_2 Max: How to calculate energy expenditure for an exercise program

- % 1-Rep Max
- McGill's Torso Muscular Endurance Test Battery

Age-Predicted Target Heart Rate

Whether your client is new to exercise or an experienced athlete, determining age-predicted Maximum Heart Rate (MHR) and calculating an appropriate intensity range, is one way to establish a safe and effective cardiovascular training program. Age-predicted mathematical formulas are used in place of a maximal-effort exercise test, which is generally not considered appropriate for most individuals.

The MHR can vary greatly between individuals due to factors such as; age, genetics, altitude, body size, medications. The common mathematical formulas that are used to estimate MHR based on age do have a varying degree of error:

(1) Fox, Naughton and Haskell: 220-age

(2) Tanaka, Monohan and Seals 208 - (0.7 x age)

Refer to ACE's Personal Trainer Manual 4th Edition pg. 375- 376

Age-Predicted Target Heart Rate

The common formula MHR = 220 – age demonstrates a standard deviation of approximately 12bpm meaning that the true MHR of an individual may differ by up to 12 bpm either side of the calculated value.

The formula 208 – (0.7 x age) was created to reduce this error and but still holds a degrees of error of a standard deviation closer to 7bpm.

Example: Louise a 60 year old sedentary female is ready to begin a walking and biking program. What is her estimated MHR that can be used to calculate exercise intensity?

- Formula (1) example: MHR = 220 – age = 220 – 60 = 160bpm
- Formula (2) example: MHR = 208 – (0.7 x age) = 208-42 = 166bpm.

Note the variation in heart rate when using the two different formulas.

Refer to ACE's Personal Trainer Manual 4th Edition pg. 375- 376

Age-Predicted Target Heart Rate

Let's walk through another example.

Using Louise from the previous example, calculate the heart rate range for Louise if she is to exercise at an intensity of 65% and 75% using the Tanaka Formula.

- MHR = 208 – (0.7 x age) = 208-42 = 166bpm.
- Multiply the desired exercise intensity:

  166 bpm x 0.65 (65%) = 107.9 = 108 bpm

  166 bpm x 0.75 (75%) = 124.5 = 125 bpm

Louise's heart rate range is 108 – 125 bpm.

Louise should begin exercise at a target heart rate of 108 – 125 bpm.

Karvonen /HR Reserve (HRR) Formula

The Karvonen/Heart Rate Reserve formula accounts for a client's current level of fitness by factoring in resting heart rate (RHR).

People who undergo regular vigorous exercise generally have reduced resting heart rates. The Karvonen formula adjusts target heart rate in response to this cardiovascular adaptation. The formula is:

(220 – age – RHR) (Intensity) + RHR = Target HR

In the next examples the (220-age) formula for MHR will be used to demonstrate the HRR. However using 208- (0.7 x age) would provide a more accurate calculation.

Refer to pg. 377 in the Personal Trainer Manual 4th ed.

Karvonen /HR Reserve (HRR) Formula

We met Louise in an earlier slide. She's 60 years old, sedentary, and has a resting heart rate of 70. We've already calculated her target heart rate using the age-predicted MHR formula. This time, let's determine her target heart rate (THR) at 65-75% of HRR.

1. Find her MHR: 220 – 60 = 160 Then find HRR: 160 – 70 = 90.
   90 is her HRR – the difference between her MHR and RHR.

2. Find THR exercising at 65% of her HRR:
   Multiply HRR (90bpm) by the intensity (0.65) = 59.
   Then add BACK the RHR [+ 70] = 129 bpm.

3. Now use the entire formula to find THR at 75% of her HRR:
   220 – 60 = 160 [– 70] = 90 x (0.75) = 68 [+ 70] = 138 bpm

Using the HRR formula, Louise has a THR of 129-138 bpm.

Karvonen Formula/HRR: A Comparison

In the previous examples, we used both age-predicted MHR and HRR for calculating Louise's target heart rate. Both are appropriate equations, but yield different results:

- The age-predicted MHR formula: THR of 104-120 bpm
- Karvonen/HRR formula: THR of 129-138 bpm.

Using the HRR formula lets you calculate exercise intensity based on Louise's existing level of fitness and RHR. As a result, she may be able to exercise at a higher intensity level. As Louise's trainer, you'll monitor her response to exercise at different intensities and adjust her workloads accordingly.

Volume of Oxygen Consumption—VO_2max

Maximal oxygen consumption, or *VO_2max,* is the maximum amount of oxygen the body can take in, process, deliver, and use at the cellular level – it's a widely used value for quantifying fitness level.

VO_2max is expressed as: mL/kg/min; the *volume* of oxygen (ml) consumed per *kg* of body weight per *minute* of exercise.

The amount of oxygen consumed determines the amount of energy burned during an exercise session. Energy is measured in calories (kcal), defined as the amount of energy required to heat 1 kg of water by 1 degree Celsius

⟶**Using 1 L of oxygen requires the body to burn 5 kcal**

Volume of Oxygen Consumption
Absolute and Relative VO_2max

Absolute VO_2 Max - the *total* amount of oxygen used during a single bout of exercise. It's measured in L/min.

Relative VO_2 Max - accounts for oxygen used relative to bodyweight; it is measured in mL per kg of bodyweight (BW) per minute of exercise. mL/kg/min

$$\frac{\text{Oxygen Uptake (mL/min) x 1,000}}{\text{Bodyweight (kg)}} = \text{L/min/kg of BW}$$

To estimate VO_2max for clients, refer to the Ross Sub-maximal Treadmill protocol in Ch. 8 of the ACE Personal Trainer Manual 4th ed. for the 1.5 mile run test.

Using Math to Determine Energy Expenditure During Exercise

$$\text{Relative } VO_2 \text{ max} : \frac{\text{Oxygen Uptake (mL/min)} \times 1{,}000}{\text{BW (kg)}} = \text{L/min/Kg BW}$$

To calculate energy expenditure during exercise, find the client's:

1. VO_2 max (Use data from a maximal or submaximal test)
2. Weight in Kg
3. Total minutes of exercise
4. Factor in 5 kcal energy expended per Liter of oxygen consumed

Refer to Ch. 11 pg. 380-381 in ACE Personal Trainer Manual 4th ed.

Using Math to Determine Exercise Energy Expenditure

Ahmad is a male client, and weighs 180 lbs. His VO_2 max is 52 ml/kg/min. Let's find out how many calories he'll burn exercising at an intensity of 75% of VO_2 max for 40min.

To determine calories, we'll first need to determine how much oxygen he'll consume during the workout.

Next we will go through the calculations step by step.

Using Math to Determine Exercise Energy Expenditure

To determine exercise energy expenditure:

1. Convert BW from lbs. to kg. (180lbs X 0.45 = 81 kg)

2. Multiply intensity of training by volume of O_2 consumed:
   (0.75 X 52mL/kg/min X 81kg = 3159 mL/min)

3. Convert ml to L. (3159ml/min/1000 = 3.16 L/min)

Ahmad will consume 3.16 L/min of O_2 during exercise

Next, we'll calculate calories burned during this workout.

Using Math to Determine Exercise Energy Expenditure

Now that we know the volume of O_2 Ahmad will consume, we can calculate the total calories he'll burn during his workout. Calories are expended at a rate of 5 kcal per L of O_2 consumed.

To find total calories burned, multiply volume of O_2 consumed by 5 kcal/L (rate of caloric burn). Then multiply that by the length of time of the exercise session:

$$3.16 \text{ L/min} \times 5 \text{ kcal/L} \times 40 \text{ min}$$

or

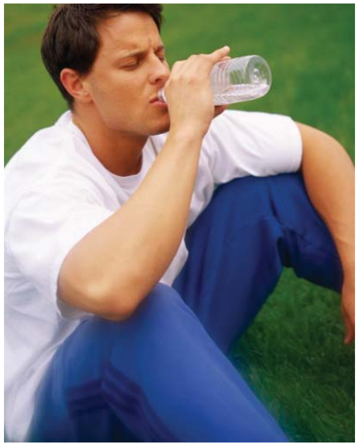
$$3.16 \times 5 = 15.8 \times 40 = 632 \text{ kcal}$$

Ahmad will burn 632 total kcal during a 40-minute exercise session when he exercises at 75% of his VO_2max.

Determining Exercise Energy Expenditure

Another way to calculate energy expenditure is to use standard values for Metabolic Equivalents (METs) and apply the following formula:

One MET is equal to the oxygen consumption/minute of the body at rest, which is 3.5 ml/kg/min. Physical activities can be expressed as a multiple of the resting MET value. Refer to Table 11-6 in the 4th ed. for the METS of many common activities.



$$\frac{\text{(METs X 3.5 X BW(kg)}}{200} = \text{kcal/min}$$

Determining Exercise Energy Expenditure

$$\frac{(\text{METs X 3.5 X BW(kg)}}{200} = \text{kcal/min}$$

From Table 11-6 pg. 381 in the 4th ed., we see that running a 10 min. mile requires about 10.2 METs. Your client, Archie, weighs 180lbs. We're going to use METs to determine Archie's energy expenditure in kcal/min when running a 10 min. mile.

1. Convert pounds to kg.: 180 X 0.45 = 81kg
2. Now multiply all the numbers in the numerator:
   (Intensity in METs X Resting MET value X BW in kg) =
   10.2 X 3.5 mL/kg/min = 35.7mL/kg/min X 81kg = 2891.7;
3. Then divide by 200
   2819.7/200 = 14.5 kcal/min

Using this formula, we can see that a 180 lb. client who runs at 10mph will burn 14.5 kcal/min.

Ventilatory Threshold Testing

Ventilatory threshold testing is based on the physiological principle of ventilation. As exercise intensity increases, ventilation increases in a somewhat linear manner, demonstrating points at certain intensities associated with metabolic changes within the body.

The first ventilatory threshold (**VT1**) is the point where lactic acid begins to accumulate in the blood and at this point an individual exercising can continue to talk comfortably while exercising. Above the VT1 threshold, as the breathing rate increases, the ability to talk continuously would become difficult. VT1 can be measured using the Submaximal Talk test which measures the HR response at VT1 by progressively increasing exercise intensity and identifying the HR where the ability to talk becomes compromised.

See pages 202- 204 in ACE's Personal Trainer Manual 4th ed.

The second ventilatory threshold (**VT2**) is the point where lactic acid accumulates rapidly in the blood and indicates an exercise intensity that can no longer be sustained. VT2 can be measured using the VT2 threshold Test which measures the HR response at VT2 using a single, high intensity 15-20minute bout of exercise.

See pages 204- 205 in ACE's Personal Trainer Manual 4th ed. *and the next slide for a worked example.*

VT2 Testing

To predict the HR response at VT2 using a 15-20minute test, trainers can estimate that the corrected HR response would be equivalent to 95% of the 15-20min HR average. For example, if an individual's average HR for a 20minute bike test is 168bpm, the HR at VT2 would be 160pbm (168 x 0.95).

Here is an example:

George completed the VT2 test on an indoor cycling bike. After a light warm up of 2-3minutes (HR below 120bpm) George began the test at a high intensity level that he could maintain for 20mins (predetermined intensity level). At the end of each 5 minutes George's HR was recorded. The average HR was then determined and this average was multiplied by 0.95 to determine the VT2 estimate.

HR Response=

Warm up:	<120bpm
End of 5th minute:	167bpm
End of 10th minute:	170bpm
End of 15th minute:	165bpm
End of 20th minute:	169bpm

Average=

167 + 170 + 165 + 169 =671

671 ÷ 4 = 167.75 = 168bpm

VT2 Estimate=

168bpm x 0.95 = 159.6 = 160pbm

Therefore the estimated HR when George has reached VT2 is 160bpm.

This test should only be used for clients who are low-moderate risk and are in Phase 3 of the ACE IFT Model.

Math for Strength Training

The % of 1-rep max (1-RM) is a standard formula that can be used for determining initial workloads for strength training.

Once you've established your client's 1-rep max for a strength exercise, multiply the 1-rep max in lbs. by the desired intensity, based on the client's goal. For muscular strength and power, the intensity is higher; for muscular endurance, the intensity is lower.

Example: Squat workload for muscular endurance when 1-RM is 110 lbs.

% 1-RM = 1-RM (lbs.) x desired intensity

% 1-RM = 110 lbs x 60% (0.60) = 66 lbs.

Initial workload should be 66 lbs. to build muscular endurance for a client with a 1-RM of 110 lbs. on the squat.

McGill's Torso Muscular Endurance Test Battery

Core stability is important for performing simple activities of daily life and for alleviating back problems.

To evaluate balanced core strength and stability it is important to assess all sides of the torso. McGill's Torso Muscular Endurance Test Battery tests the endurance of three torso muscle groups:

- Trunk Flexor Endurance Test: assesses muscular endurance of the anterior deep core muscles.
- Trunk Lateral Endurance Test: also called the side bridge test, assesses muscular endurance of the lateral core muscles.
- Trunk Extensor Endurance Test: assesses muscular endurance of the torso extensor muscles.

Poor endurance of the torso muscles or an imbalance between the three muscle groups can contribute to low back pain and core instability.

Refer to ACE's Personal Trainer Manual 4th ed. pg. 217-220

McGill's Torso Muscular Endurance Test Battery: The Three Ratios

The tests are performed individually and involve a static, timed isometric contraction of the core muscles stabilizing the spine until the individual exhibits fatigue. Refer to ACE's Personal Trainer Manual 4th ed. pg. 217-220 for test instructions.

The results are then evaluated collectively in the following ratios to indicate balanced endurance among the muscle groups:

- Flexion:Extension – the ratio should be less than 1.0
- Right-side Bridge (RSB):Left-side Bridge (LSB)
  - – score should be no greater than 0.05 from a balanced score of 1.0
- Side Bridge (either side):Extension
  - – score should be less than 0.75

Refer to ACE's Personal Trainer Manual 4th ed. pg. 217-220

McGill's Torso Muscular Endurance Test Battery: The Three Ratios

Let's work through an example:

Lauren completed the three tests with the following results:

Flexor test: 120 seconds | RSB: 88 seconds

Extension test: 150 seconds | LSB: 92 seconds

- Flexion:Extension = 120:150 = 120/150 = 0.8
  The score of 0.8 fits with the criteria of <1.0
- RSB:LSB = 88:92 = 88/92 = 0.96 (0.956 rounded up)
  This score sits within the 0.05 range from 1.0
- Side Bridge:Extension = using RSB = 88:150 = 88/150 = 0.59 (0.586 rounded up)
  This score fits with the criteria of <0.75

The results show that Lauren has well balanced torso muscles.

Nutrition Math:
Caloric Value of Macronutrients

Math can be used to determine caloric value of food based on label information –number of servings, serving size, macronutrient amounts (carbohydrate, protein, fat and alcohol), and % of calories from specific macronutrients.

Nutrition math, combined with equations that estimate energy expenditure, can be used to help your clients adjust and monitor energy intake, boost caloric expenditure and achieve their weight goals.

Fitness Math:
Caloric Value of Macronutrients

Each macronutrient provides a specific amount of energy per gram. Use these values to help clients read food labels and determine the nutritional value of food per serving:

1 g of protein provides 4 calories of energy.

1 g of carbohydrate provides 4 calories of energy.

1 g of fat provides 9 calories of energy.

1 g of alcohol provides 7 calories of energy.

Caloric Values of Food Based on Levels of Macronutrients

Teaching clients how to calculate nutrient intake based on food labels is a good idea. This ensures that they know what they're eating and can help them verify the accuracy of food label information.

Example:
The following information is provided for a common energy bar. To determine the number of calories, multiply the number of grams of a given macronutrient by the appropriate energy/gram:

11g protein	11g X 4 kcal/g = 44 kcal
36g carbohydrate	36g X 4 kcal/g = 144 kcal
8g fat	8g X 9 kcal/g = 72 kcal

Total = **260 kcal**

Calculating Percentage of Calories from Specific Macronutrients

The following problems, using data from the previous slide, show how to determine the percentage of calories from a specific macronutrient. This can be helpful when recommending that a client choose food items that are less than 30% fat. Keep in mind, however, that it's the average daily fat intake that counts for health, not just the % fat for one meal or one food item.

Total kcal = 260 kcal

Fat kcal/total kcal = % of kcal from fat

72/260 = 28% (0.276) of kcal are from fat

Protein kcal/total kcal = % of kcal from protein

44/260 = 17% (0.169) of kcal are from protein

Carbohydrate kcal/total kcal = % of kcal from carbohydrate

144/260 = 55% (0.55) of kcal from carbohydrate

Nutrition Math
Calculating Weight Loss Success

1 lb. of fat = 3500 kcal

To promote safe and effective weight loss, you'll need to help your clients create a negative energy balance of 3500-7000 calories per week. This energy deficit should produce weight loss of 1-2 lbs. per week, a rate recommended by health experts.

The best approach is a combination of reduced energy intake – cutting back on total calories – plus increased energy expenditure through exercise.

Nutrition Math
Calculating Weight Loss Success

Your clients can lose up to 1-2 lb/fat per week by combining increased caloric expenditure with reduce caloric intake, thereby creating a negative caloric balance of 500 -1000 kcal/day.

Example:

If Lana, a 140 lb. woman, rides her bike for 40 min. at 75% VO_2 max, 4-5 days/week, and substitutes water for a daily frozen coffee drink, she'll achieve a daily deficit of 500-1000 kcal.
At this rate, Lana should lose 1-2 lbs a week.

Nutrition Math
Calculating Weight Loss Success

Let's look at another example:

Tanya would like to lose 25 pounds over the next 20 weeks. If she agrees to increase her physical activity level by 300kcal per day, how many calories should she reduce from her daily intake to reach this goal?

1) Calculate the total amount of calorie deficit that will reduce her weight by 25 pounds: **25lbs x 3500 (1lb fat) = 87500 kcal total**
2) Divide the total amount by 20 weeks to find the calorie deficit per week: **87500/20 = 4375 kcal per week**
3) Divide the total calorie deficit per week by 7 to find the calorie deficit needed per day: **4375/7 =625 kcal per day**
4) Minus the 300 kcal per day for her physical activity to find the amount of calories she needs to reduce from her daily intake: **625 – 300 =325 kcal**

Therefore Tanya must reduce her daily intake by 325 calories per day to lose 25 pounds over the next 20 weeks with the physical activity increase.

Applying Math for Client Results

Developing exercise programs using the formulas and math covered in this course will give you the ability to produce the results your clients want and the confidence you need to succeed.

By quantitatively assessing your client’s current fitness levels, developing scientifically based exercise programs and measuring progress you establish yourself as a serious *ACE Fitness Professional.*

Fitness Math: Additional Resources

Visit these tutorial sites for additional practice on math concepts covered in this course:

www.aaamath.com

www.math.com