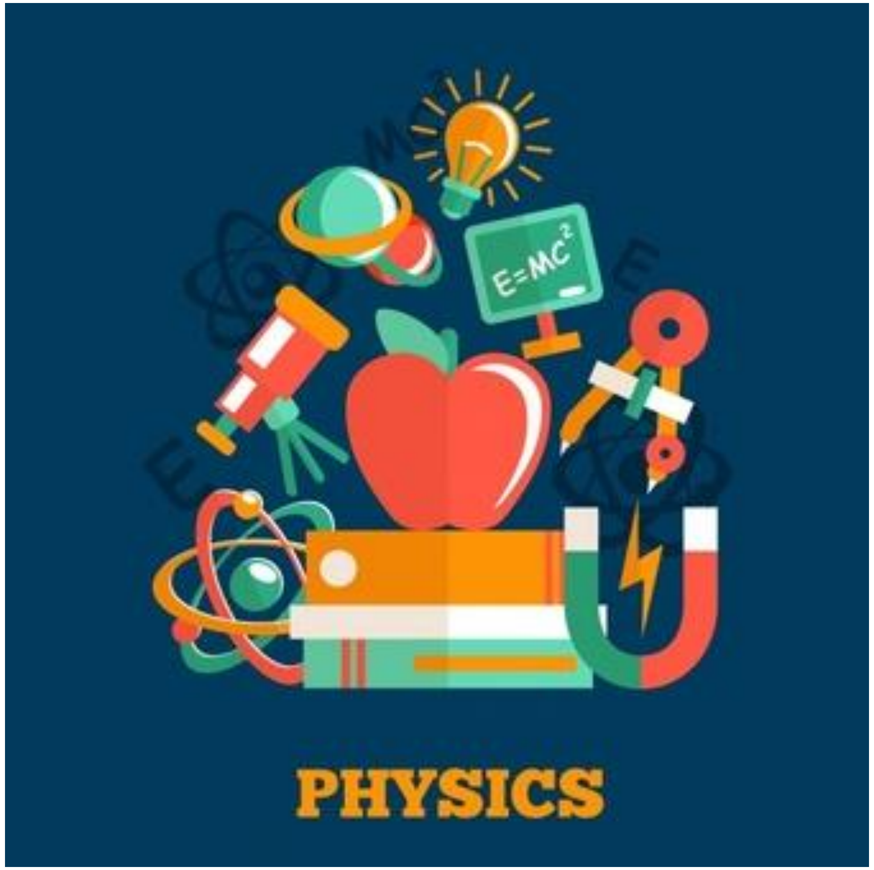
Physics I



How to Succeed in Physics

- Spend time studying
- Do not miss classes
- Treat problem sets, labs, quizzes and exams as opportunities for learning – not just to get grades
- Approach Physics problems systematically
- Do more than what your instructors ask
- Use all available resources

Use the textbook for more details

Most of the work is done outside class

Read syllabus
Understand course and marks

Take Class

Review work

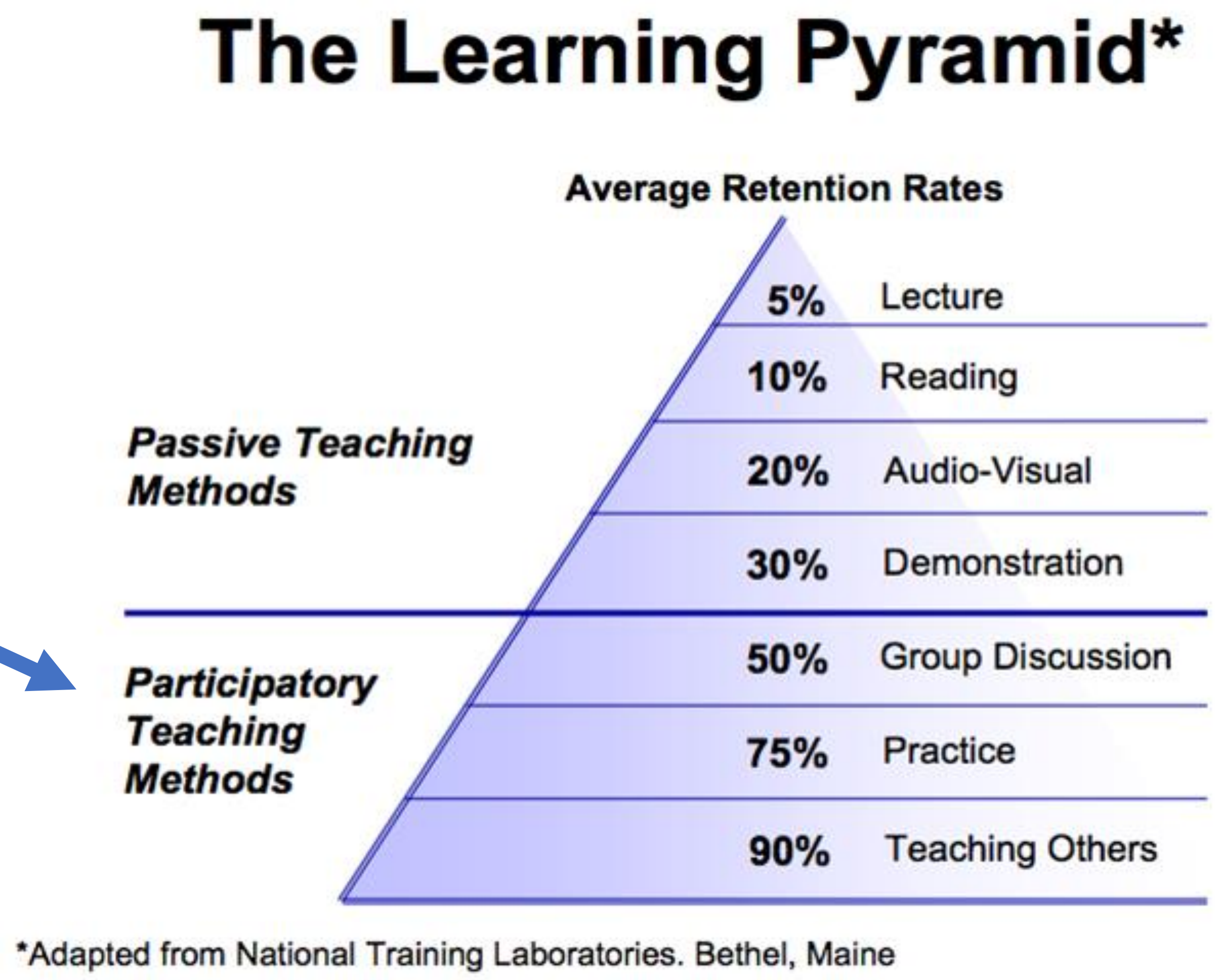
Sort out difficulties

Review work to remind you about last class and look ahead to next class (power point etc.)

HW
Revision
Assessments

Making notes during lesson is being more active

Be active in class



Basics objectives

Use SI and English units as appropriate and convert between these systems as needed

- **I can rearrange equations.**
- I can use trigonometry to solve problems.
- I know the SI base units of length, mass, time, absolute temp and current.
- I know prefixes femto to Tera
- I can quote the correct significant figures in my answers

Measurement

- Physics is an experimental science.
  - Observe phenomena in nature.
  - Make predictions.
    - Models
    - Hypotheses
    - Theories
    - Laws

(a)

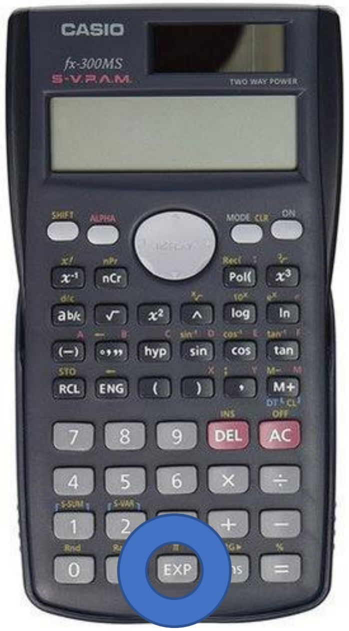
Mathematics Review

1. Scientific notation and powers of ten

- The mass of the earth is approximately

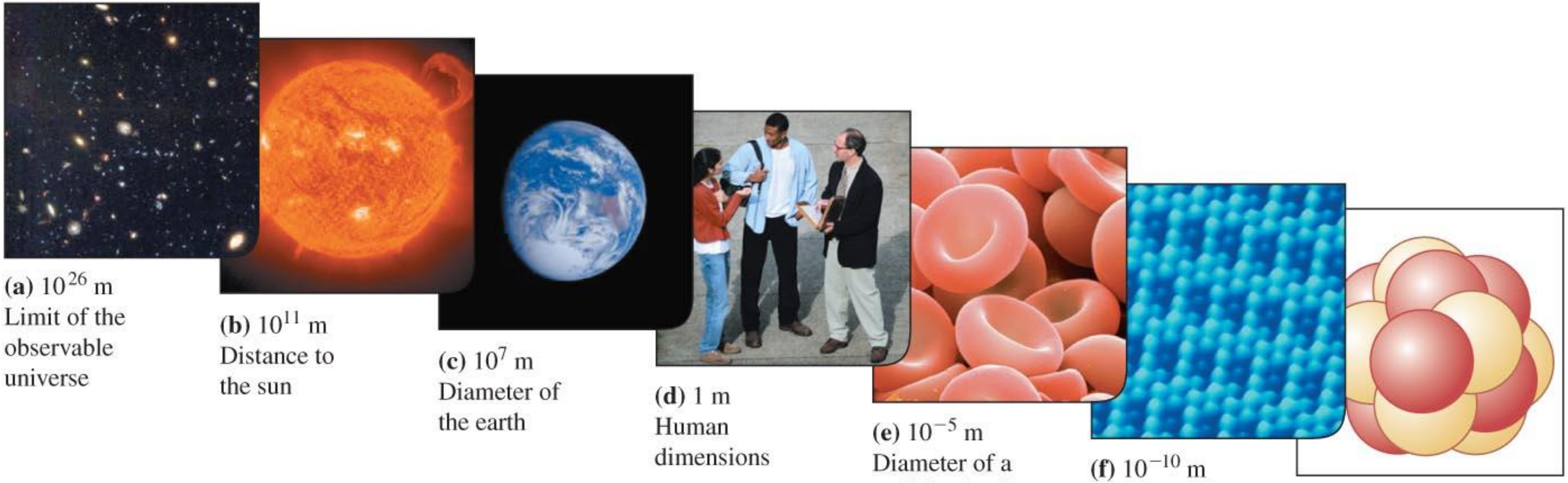
6,000,000,000,000,000,000,000,000 kg

- **The** mean covalent radius of hydrogen is 0.000000000031 m.



- A number written in scientific notation is in decimal form with **only one digit to left** of the decimal point and the appropriate power of ten.

The Powers of Ten are Dramatic



(a) 10^{26} m
Limit of the observable universe

(b) 10^{11} m
Distance to the sun

(c) 10^{7} m
Diameter of the earth

(d) 1 m
Human dimensions

(e) 10^{-5} m
Diameter of a red blood cell

(f) 10^{-10} m
Radius of an atom

(g) 10^{-14} m
Radius of an atomic nucleus

Table 1.1

TABLE 1.1 Prefixes for powers of ten

Power of ten	Prefix	Abbreviation
10^{-18}	atto-	a
10^{-15}	femto-	f
10^{-12}	pico-	p
10^{-9}	nano-	n
10^{-6}	micro-	μ
10^{-3}	milli-	m
10^{-2}	centi-	c
10^{3}	kilo-	k
10^{6}	mega-	M
10^{9}	giga-	G
10^{12}	tera-	T
10^{15}	peta-	P
10^{18}	exa-	E

You need to remember these

Sinclair ZX81

Release date	5 March 1981
Memory	1 KB Expandable unit (64 KB max. 56 KB usable)

38 years
about
10^9 increase

2019

PHYS111 tutorial examples.pdf	310 KB
PHYS111 Exam cover and equation temp...	246 KB
PHYS111 Marking Scheme.docx	12 KB

Rearranging equation Practice

DO THE SAME THING BOTH SIDES

Mathematics Review

2. **Rearranging mathematical statements**

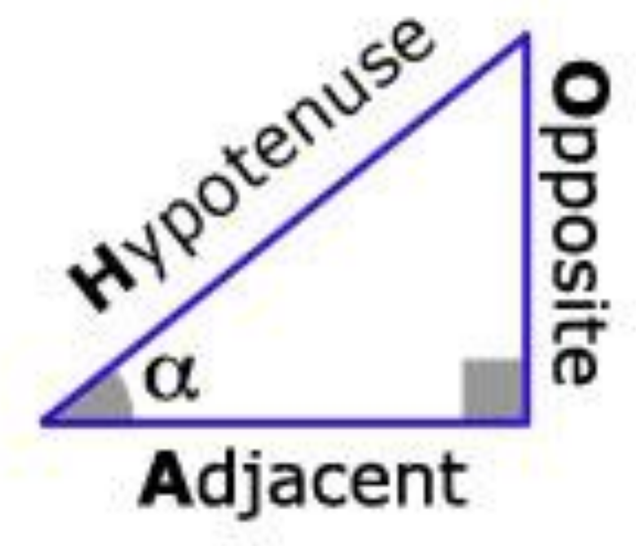
- Example 1
  Make t the subject of the equation
  $a = \frac{v - v_0}{t}$
- Example 2
  Solve $W = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$ for x

TASK

$$a = \frac{v - v_0}{t}$$

$$W = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

Mathematics Review



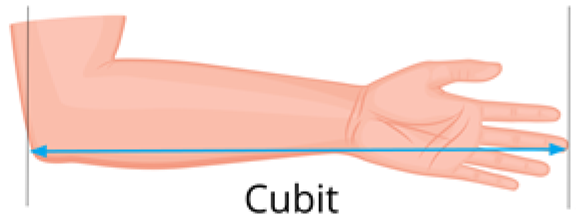
$$\text{sine}\ \alpha = \frac{\textbf{O}\text{pposite}}{\textbf{H}\text{ypotenuse}}$$

$$\text{cosine}\ \alpha = \frac{\textbf{A}\text{djacent}}{\textbf{H}\text{ypotenuse}}$$

$$\text{tangent}\ \alpha = \frac{\textbf{O}\text{pposite}}{\textbf{A}\text{djacent}}$$

SOH CAH TOA

Units of Measurement



- Cultural
  - "cubit," "span," "foot," "mile"
  - Changes with time and location

- 1889 by the General Conference on Weights and Measures
  - Systéme International (SI) (m,Kg,s)

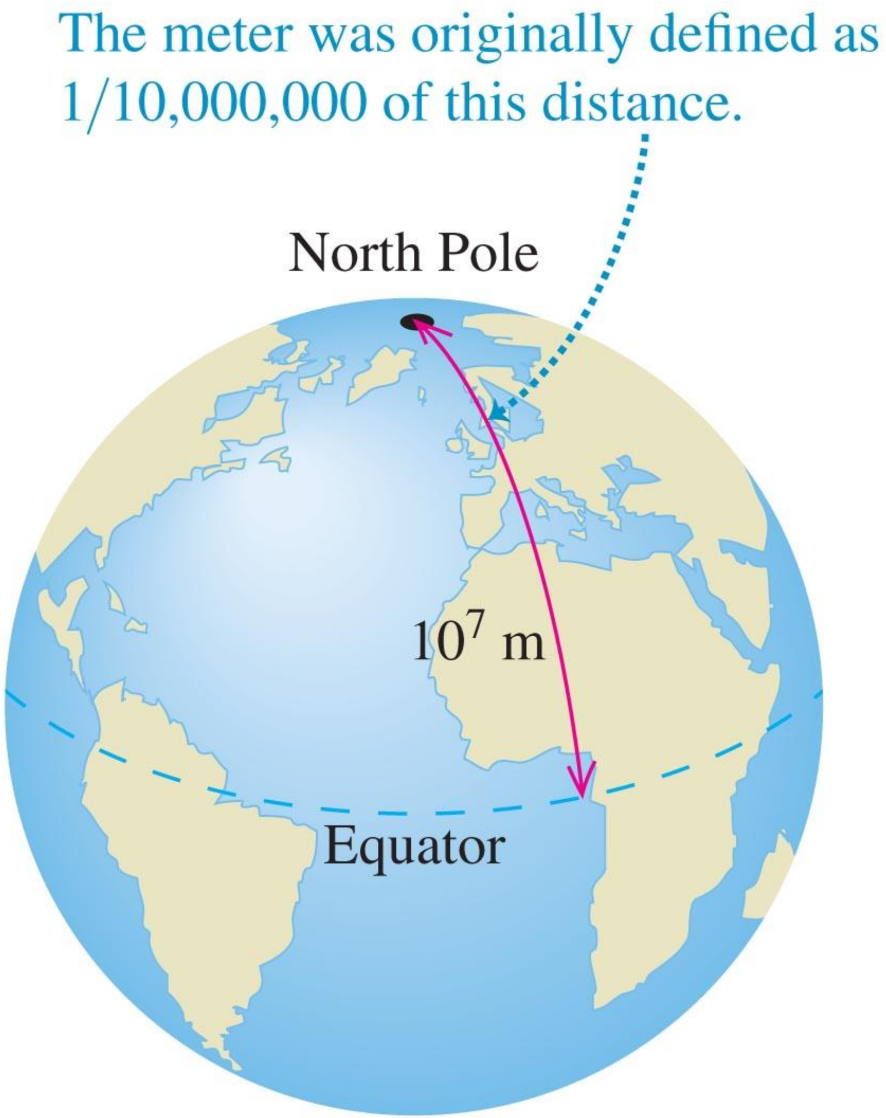
The Second

- Originally tied to the length of a day.

- Now, exceptionally accurate.
  - Atomic clock
  - 9,192,631,770 oscillations of a low-energy transition in Cs
  - In the microwave region

The Meter – The Original Definition of 1791

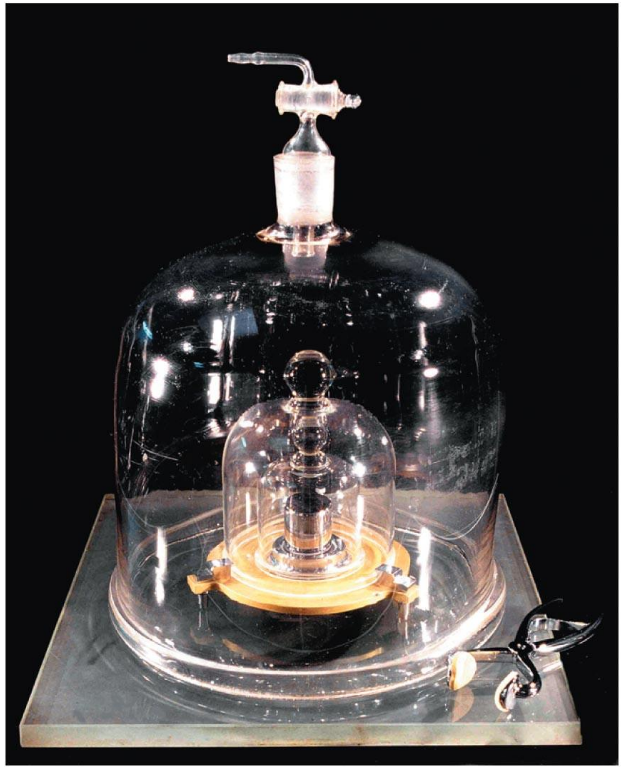
These use to be on buildings for reference



The Meter – More Recently

- Now tied to Kr discharge and counting a certain number of wavelengths.
- Exceptionally accurate, in fact redefining *c*, speed of light.
- New definition is the distance that light can travel in a vacuum in 1/299,792,458 s.
- So accurate that it loses only 1 second in 30 million years.

The Reference Kilogram



Up until 2019

The kilogram (kg) is defined by taking the fixed numerical value of the Planck constant h to be $6.626{,}070{,}150 \times 10^{-34}$ when expressed in the unit J s, which is equal to kg m^2 s^1, where the meter and the second are defined in terms of c and $\Delta\nu$.

International System of units (SI)

- The SI has **base** and **derived** quantities and units

Base Quantity	Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Absolute temperature	Kelvin	K
Electric current Intensity	Ampère	A

Also known as the mks system

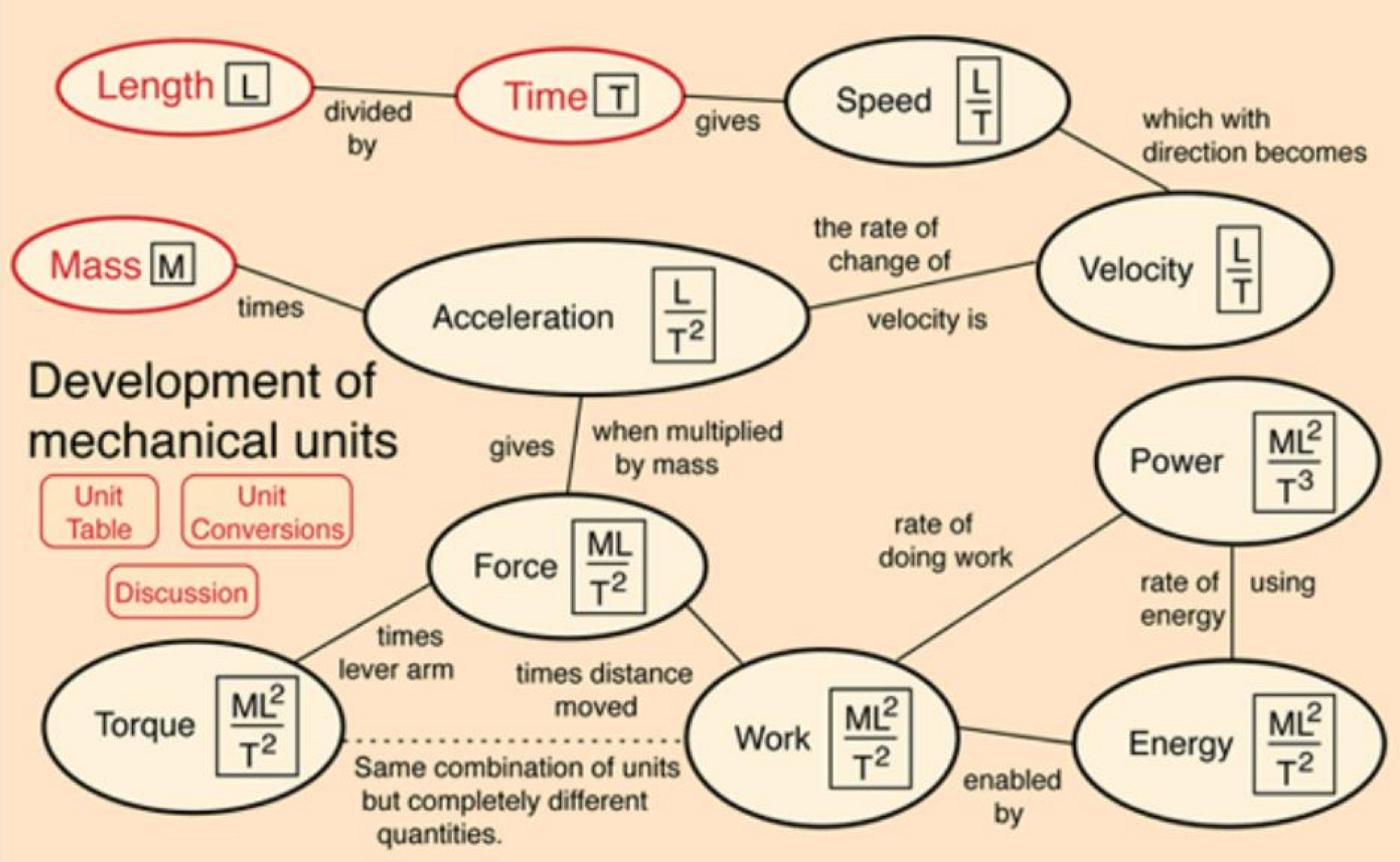
International System of units (SI)

- **Derived units** are found from base units using the same mathematical relationships that relates derived quantities to base quantities.
- For example:
- $Volume = length \times length \times length$
- $V = l \times l \times l = l^3$
- $\therefore unit\ of\ volume = (unit\ of\ length)^3$

Basic Mechanical Units

	SI Units (MKS)	(CGS)	U.S. Common
Length (L)	meter (m)	centimeter (cm)	foot (ft)
Time (T)	second (s)	second (s)	second (s)
Mass (M)	kilogram (kg)	gram (gm)	slug
Velocity (L/T)	m/s	cm/s	ft/s
Acceleration (L/T^2)	m/s^2	cm/s^2	ft/s^2
Force (ML/T^2)	kg m/s^2=Newton(N)	gm cm/s^2= dyne	slug ft/s^2=pound(lb)
Work (ML^2/T^2)	N m = joule (j)	dyne cm = erg	lb ft = ft lb
Energy (ML^2/T^2)	joule	erg	ft lb
Power (ML^2/T^3)	j/s = watt (W)	erg/s	ft lb/s

http://hyperphysics.phy-astr.gsu.edu/hbase/units.html#uni4


Length L
divided by
Time T
gives
Speed L/T
which with direction becomes
Velocity L/T
the rate of change of
velocity is
Mass M
times
Acceleration L/T2
Development of mechanical units
Unit Table
Unit Conversions
Discussion
gives
when multiplied by mass
Force ML/T2
times lever arm
times distance moved
Torque ML2/T2
Same combination of units but completely different quantities.
Work ML2/T2
rate of doing work
Power ML2/T3
rate of energy
using
enabled by
Energy ML2/T2

Unit Consistency (Homogeneity)

- Calculate:
  - 3.0 m + 4.0 m = 7.0 m
  - 2.0 m + 400 kg = ?

- Equations must be **dimensionally consistent (homogeneous)**. i.e. all terms in an equation must have the same units across a plus, minus or equals sign.

Conversion examples

Here we will do a simple conversion of units. Although there is no maximum speed limit on the German autobahn, signs in many areas recommend a top speed of 130 km/h. Express this speed in meters per second and in miles per hour.

SOLUTION

SET UP We know that 1 km = 1000 m. From Appendix D or the inside front cover, 1 mi = 1.609 km. We also know that 1 h = 60 min = 60 × (60 s) = 3600 s.

SOLVE We use these conversion factors with the problem-solving strategy outlined above:

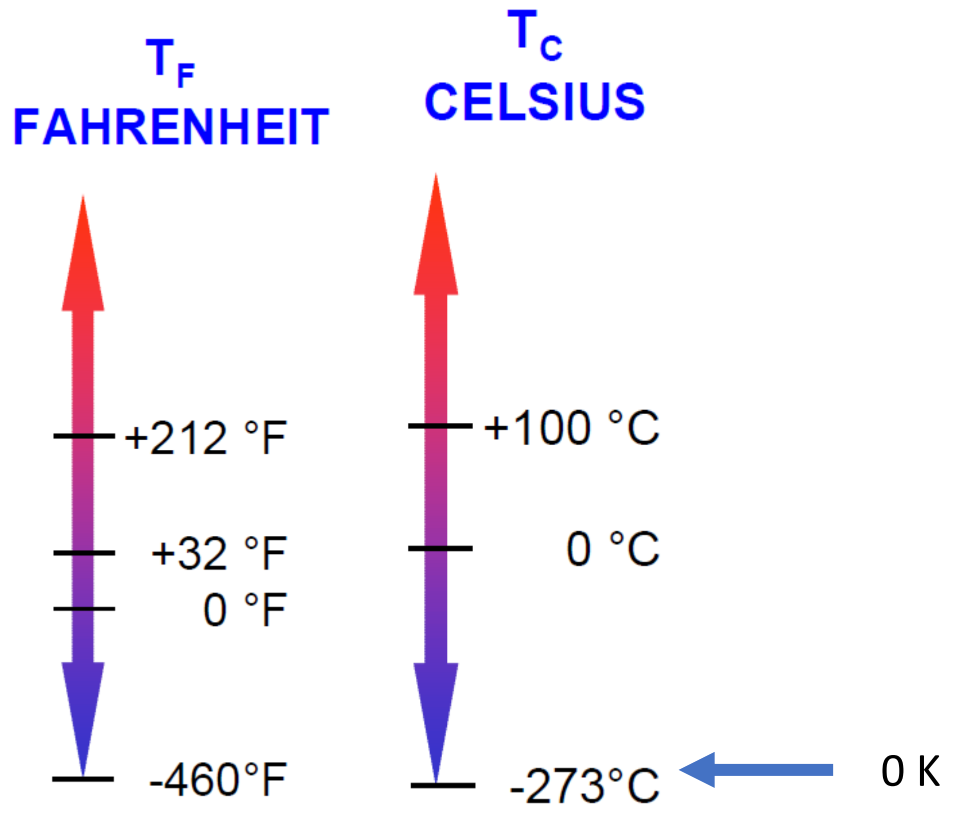
$$130\ \mathrm{km/h} = \left(\frac{130\ \cancel{\mathrm{km}}}{1\ \cancel{\mathrm{h}}}\right)\left(\frac{1000\ \mathrm{m}}{1\ \cancel{\mathrm{km}}}\right)\left(\frac{1\ \cancel{\mathrm{h}}}{3600\ \mathrm{s}}\right) = 36.1\ \mathrm{m/s},$$

$$130\ \mathrm{km/h} = \left(\frac{130\ \cancel{\mathrm{km}}}{1\ \mathrm{h}}\right)\left(\frac{1\ \mathrm{mi}}{1.609\ \cancel{\mathrm{km}}}\right) = 80.8\ \mathrm{mi/h}.$$

VTS Ex 1.1

Temperature scales (requires a formula to convert)

- Relative temperature scales
  - These scale provide a means of comparing *relative* energy content
  - $T(°\mathrm{F}) = \frac{9}{5} T(°\mathrm{C}) + 32$



"Am I significant?"

- Try this. Divide 10 (one SF) by 3 (one SF) and your calculator will tell you 3.33333333.
- If you report this answer, the reader will believe you have measured carefully to billionths of the unit you are using.
- What can happen? It's possible that bolt holes will fail to line up.

Significant digits/figures/numbers

Definitions

Approximate --- measure
Exact ----- count

Accuracy:
the number of significant digits a number has.

Precision:
the decimal position of the last significant digit.

Significant digits/figures/numbers

Any 0 that is **just** used to place the decimal point is **in**significant

If a 0 is between two significant numbers, it is significant. Any non-zero is always significant.

100	1 sig
101	3 sig
0.001	1 sig
0.101	3 sig
1	1 sig
1.00	3 sig

The difference between 20 and 20.0 is the difference between 1 and 3 significant figures

20 could be any number between 24.999999 to 15
20.0 could be any number between 20.049999 to 19.95

2041.2 has 5 significant figures and 1 decimal place

0.006 has 1 significant figure and 3 decimal places

When **adding or subtracting approximate** numbers, keep as many decimal places in your answer as contained in the number having the **fewest decimal places.**

2041.2 + 0.006 = 2041.206

BUT the fewest decimal places is 1 (2041.2) so our answer is quoted to 1 decimal place = **2041.2**

When **multiplying or dividing** 2 or more approximate numbers, round the result to as many digits as are in the factor having the **fewest significant digits**.

2041.2 * 0.006 = 12.2472

BUT 0.006 has only **1** significant digit so the answer is = **10**

THIS IS FOR **APPROXIMATE** NUMBERS.

examples

Express the following expressions in scientific notation:

5. 475000

6. 0.00000472

7. 123×10^{-6}

8. $\dfrac{8.3 \times 10^{5}}{7.8 \times 10^{2}}$

15. • Express each of the following numbers to three, five, and eight significant figures: (a) $\pi = 3.141592654\ldots$, (b) $e = 2.718281828\ldots$, (c) $\sqrt{13} = 3.605551275\ldots$

11. The surface area of a typical classroom floor is closest to

A. $1\ cm^2$
B. $1\ m^2$
C. $10\ m^2$
D. $100\ m^2$

Do 5,6, 15a, 11

0.5. Set Up and Solve: The decimal point must be moved 5 places to the left to change 475000 into a number between 1 and 10. Thus, we have $475000 = 4.75\times10^5$.

Reflect: When written in scientific notation, numbers larger than 1 will have positive exponents and numbers smaller than 1 will have negative exponents for their power of ten.

0.6. Set Up and Solve: The decimal point must be moved 6 places to the right to change 0.00000472 into a number between 1 and 10. Thus, we have $0.00000472 = 4.72\times10^{-6}$.

Reflect: When written in scientific notation, numbers larger than 1 will have positive exponents and numbers smaller than 1 will have negative exponents for their power of ten.

***0.7. Set Up and Solve:** The decimal point must be moved 2 places to the left to change 123 into a number between 1 and 10. Thus, we have $123\times10^{-6} = 1.23\times10^2\times10^{-6} = 1.23\times10^{-4}$.

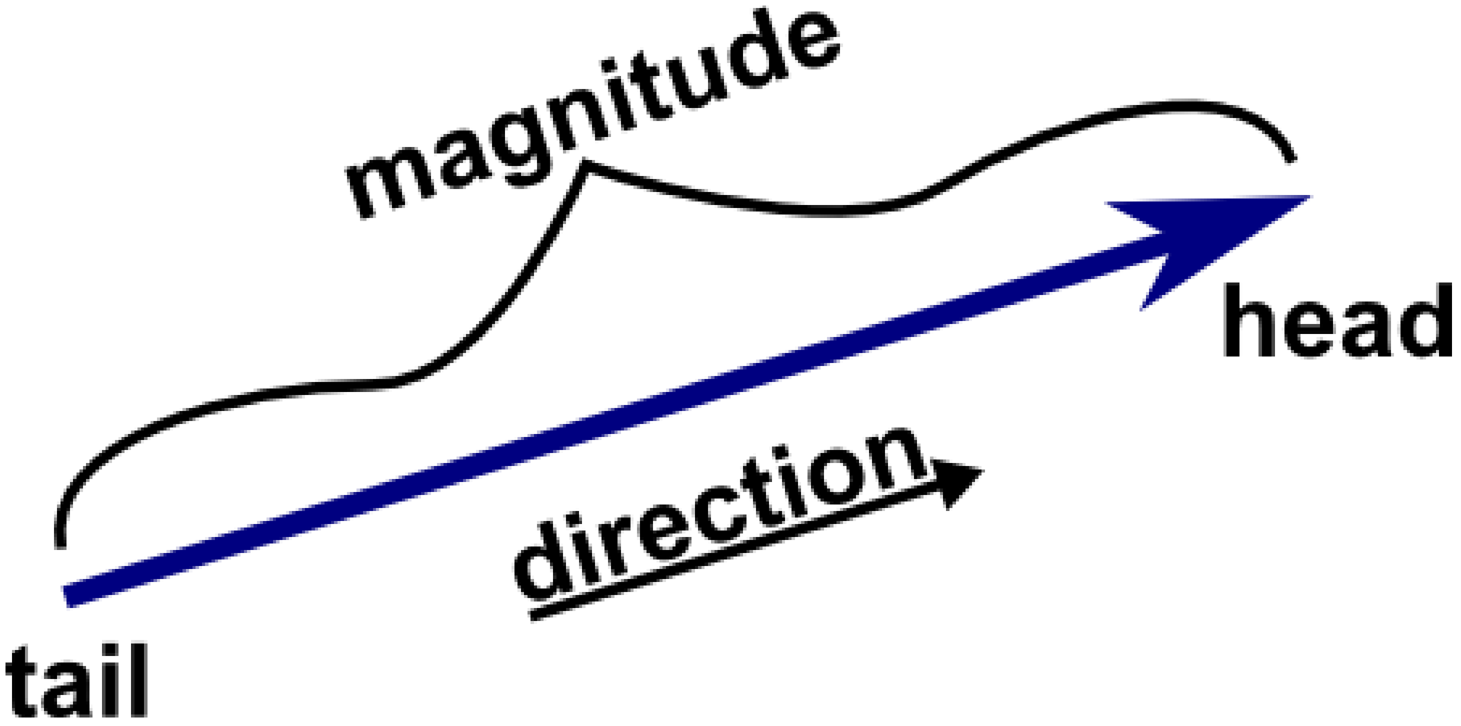
0.8. Set Up and Solve: $\frac{8.3\times10^5}{7.8\times10^2} = \frac{8.3}{7.8}\times10^{(5-2)} = 1.1\times10^3$, where we have rounded the decimal number to the nearest tenth.

Reflect: You can make a quick estimate, to check your result, by rounding each number to the nearest power of ten. Thus, we have the estimate $\frac{8.3\times10^5}{7.8\times10^2} = \frac{10^6}{10^3} = 10^3$, which can be done without a calculator.

1. B **11. D**

1.15. Set Up: In each case, round the last significant figure.
Solve: **(a)** 3.14, 3.1416, 3.1415927 **(b)** 2.72, 2.7183, 2.7182818 **(c)** 3.61, 3.6056, 3.6055513
Reflect: All of these representations of the quantities are imprecise, but become more precise as additional significant figures are retained.

Vectors



Learning objectives

- I know the difference between scalar and vector quantities.
- I can solve vectors graphically
- I can analytically add (and subtract) vectors

Agenda

- Types of quantities
- Graphical addition of vectors
- Components of vectors
- Analytical method for vector addition

Scalar and Vector Quantities

- Scalar quantities have a magnitude only, but no direction.

- Vector quantities are defined by ***both*** their magnitude *and* direction.

Representation of vectors

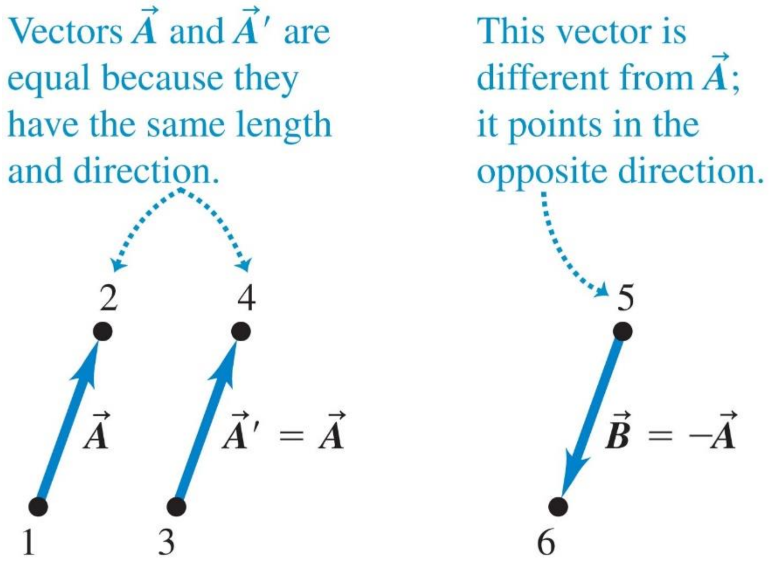
- Vectors are represented by arrows.
- **Length** of arrow is *proportional* to magnitude of physical quantity
- **Direction** of arrow is the *same* as that of the physical quantity

Graphical Addition of vectors

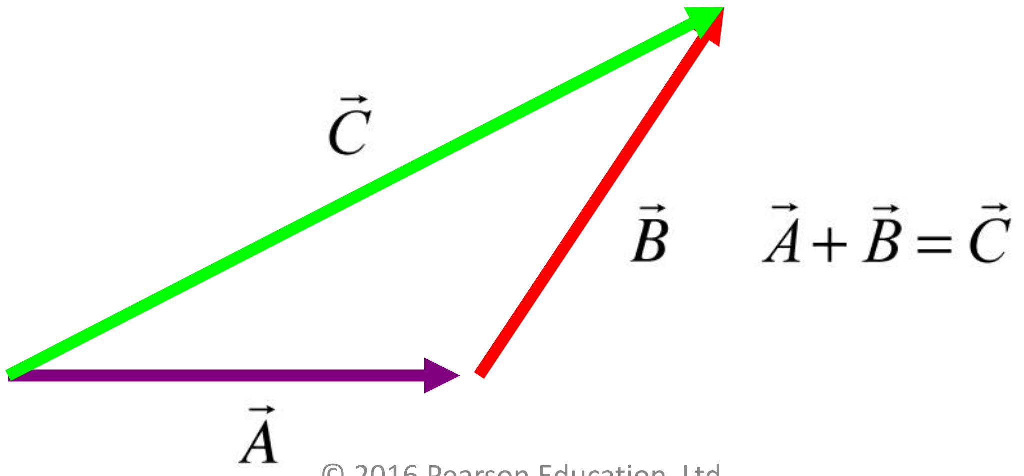
1. Choose an *appropriate* scale
2. Select a starting point and draw any vector from that point.
3. From the end of the first vector, draw the second vector.
4. From the end of the second vector, draw the third vector and so on.
5. Draw the **Resultant** from the beginning of the *first* vector to the end of the *last* vector.

Vector addition

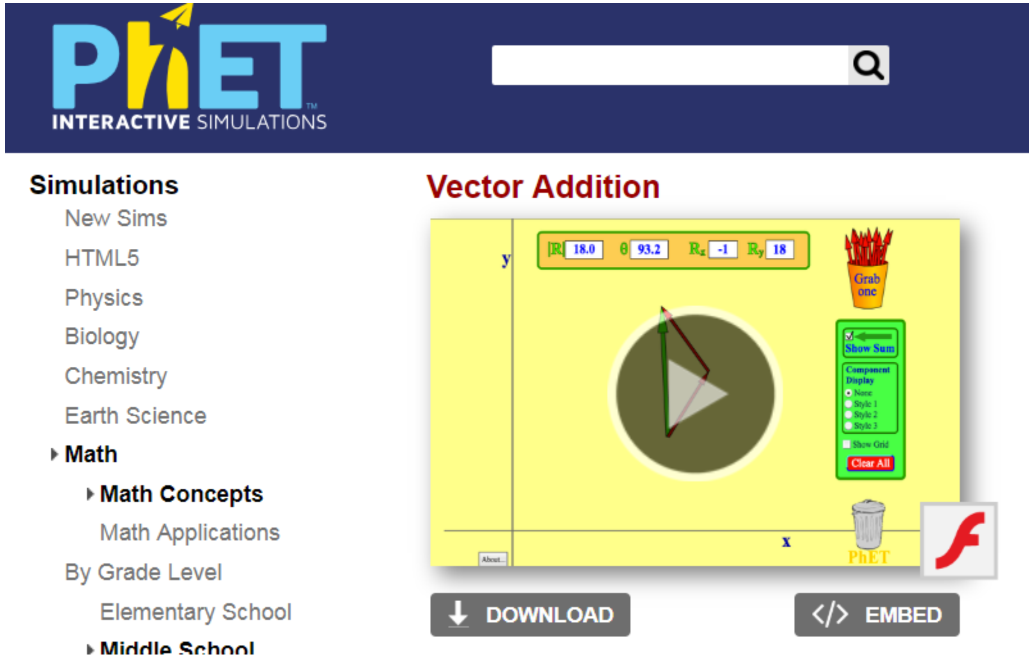
- In the "world of vectors" 1+1 does not necessarily equal 2.
- Graphically?



Adding graphically



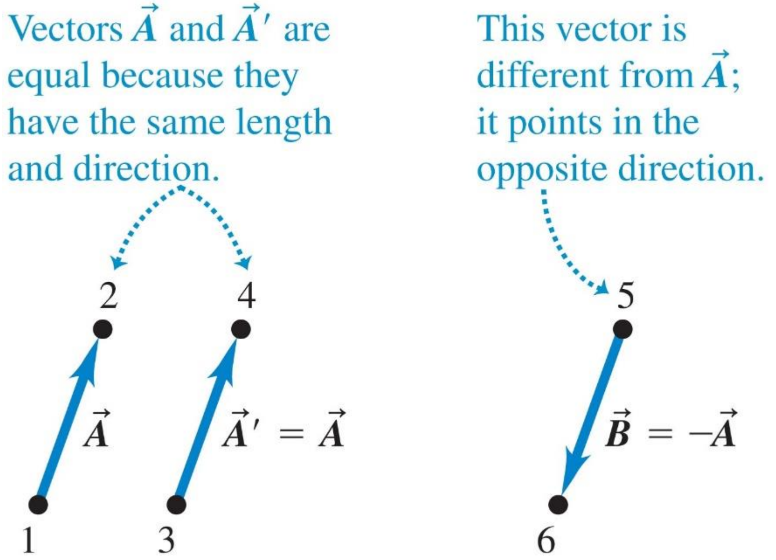
PhET Vector addition

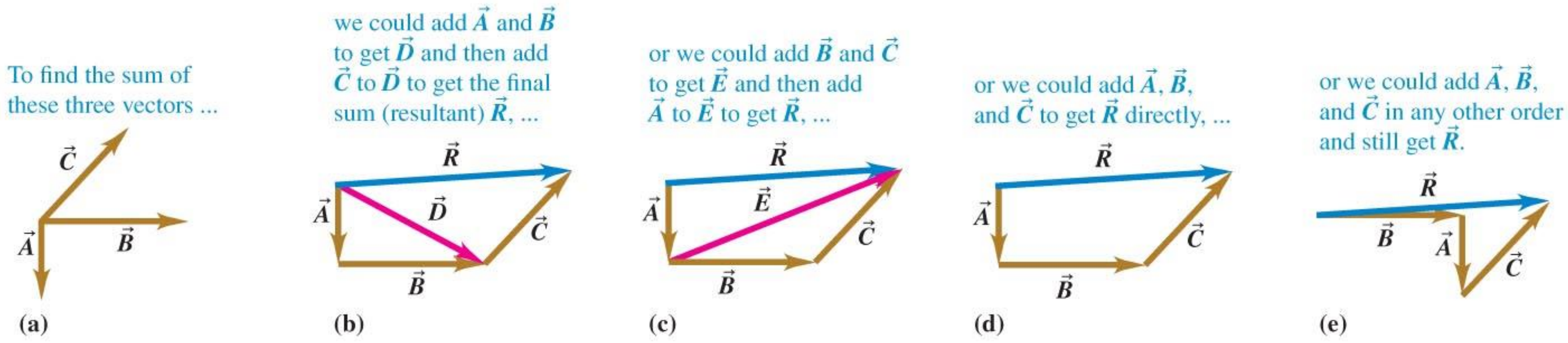


https://phet.colorado.edu/en/simulation/vector-addition

Vector addition

- In the "world of vectors" 1+1 does not necessarily equal 2.
- Graphically?





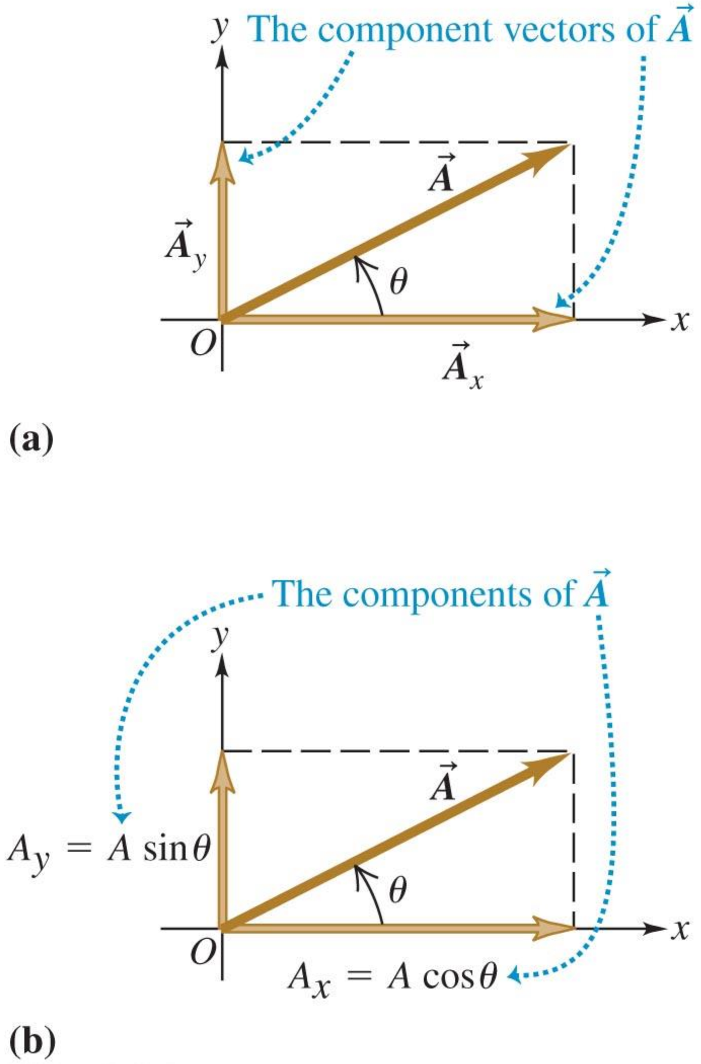
Example 1a

Two rescue helicopters are pulling up a crashed truck using two cables. The tensions in the cables are 30 kN and 50 kN. The angle between the cables is 80°.

Find the magnitude of the resultant force acting on the truck due to the cables.

Solve graphically only

Or, decompose the vectors into components, then solve.



vector $\vec{A}$ as a sum of component vectors

$$\vec{A} = \vec{A}_x + \vec{A}_y$$

vector component of $\vec{A}$

$$A_x = A \cos \theta$$

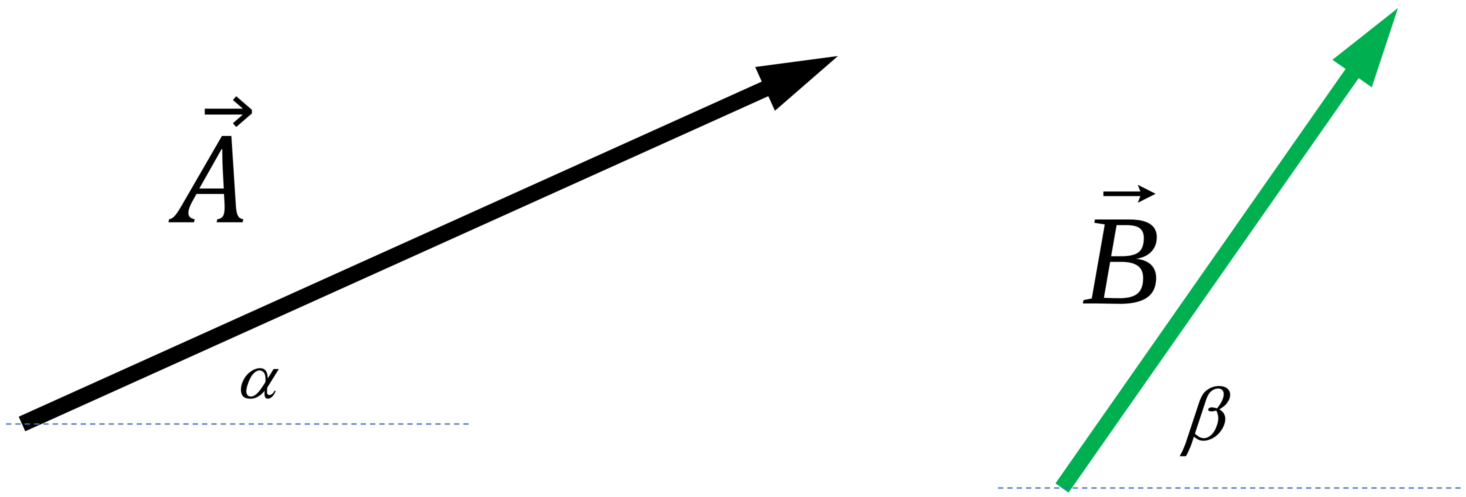
$$A_y = A \sin \theta$$

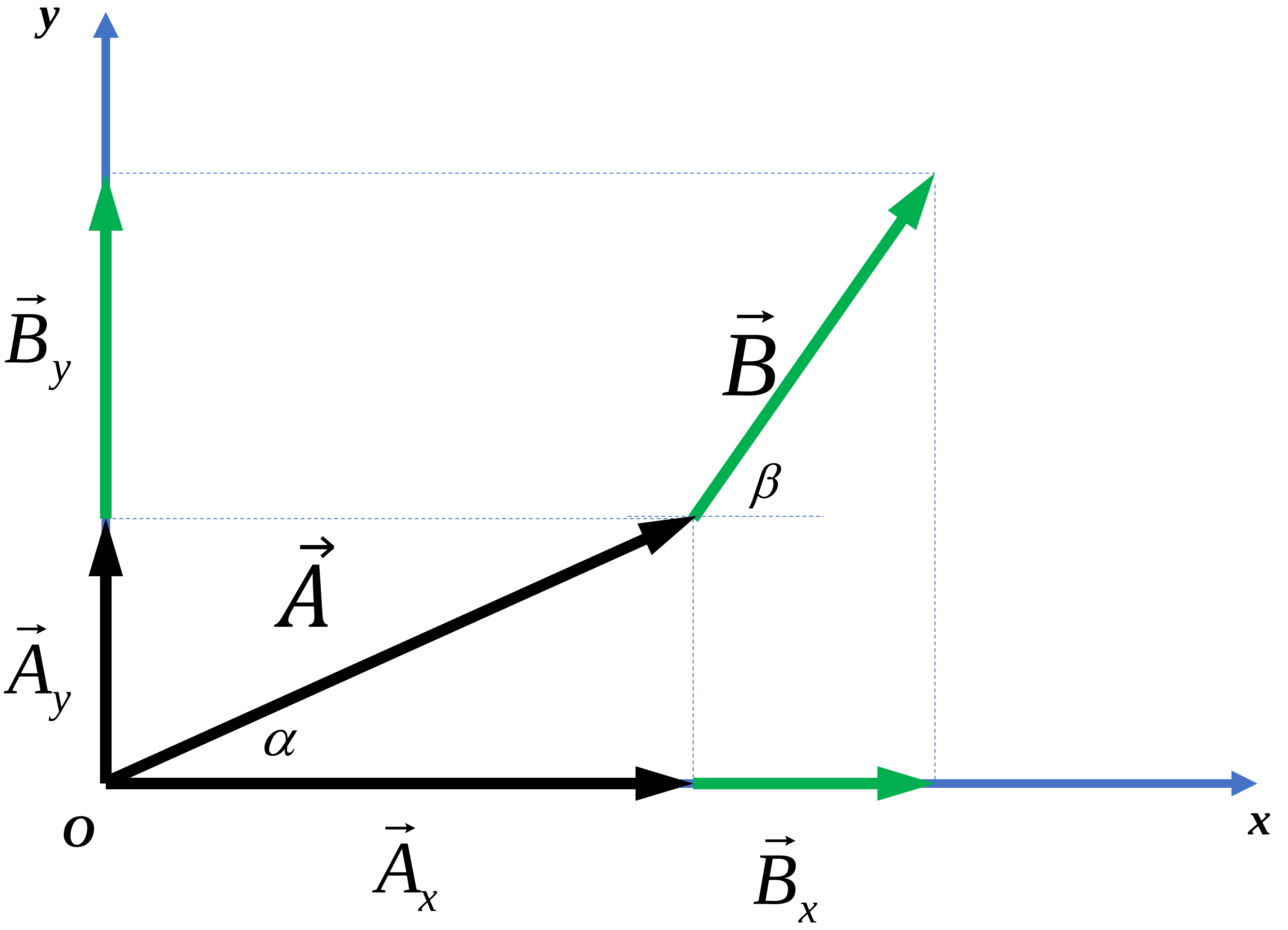
magnitude and direction of $\vec{A}$

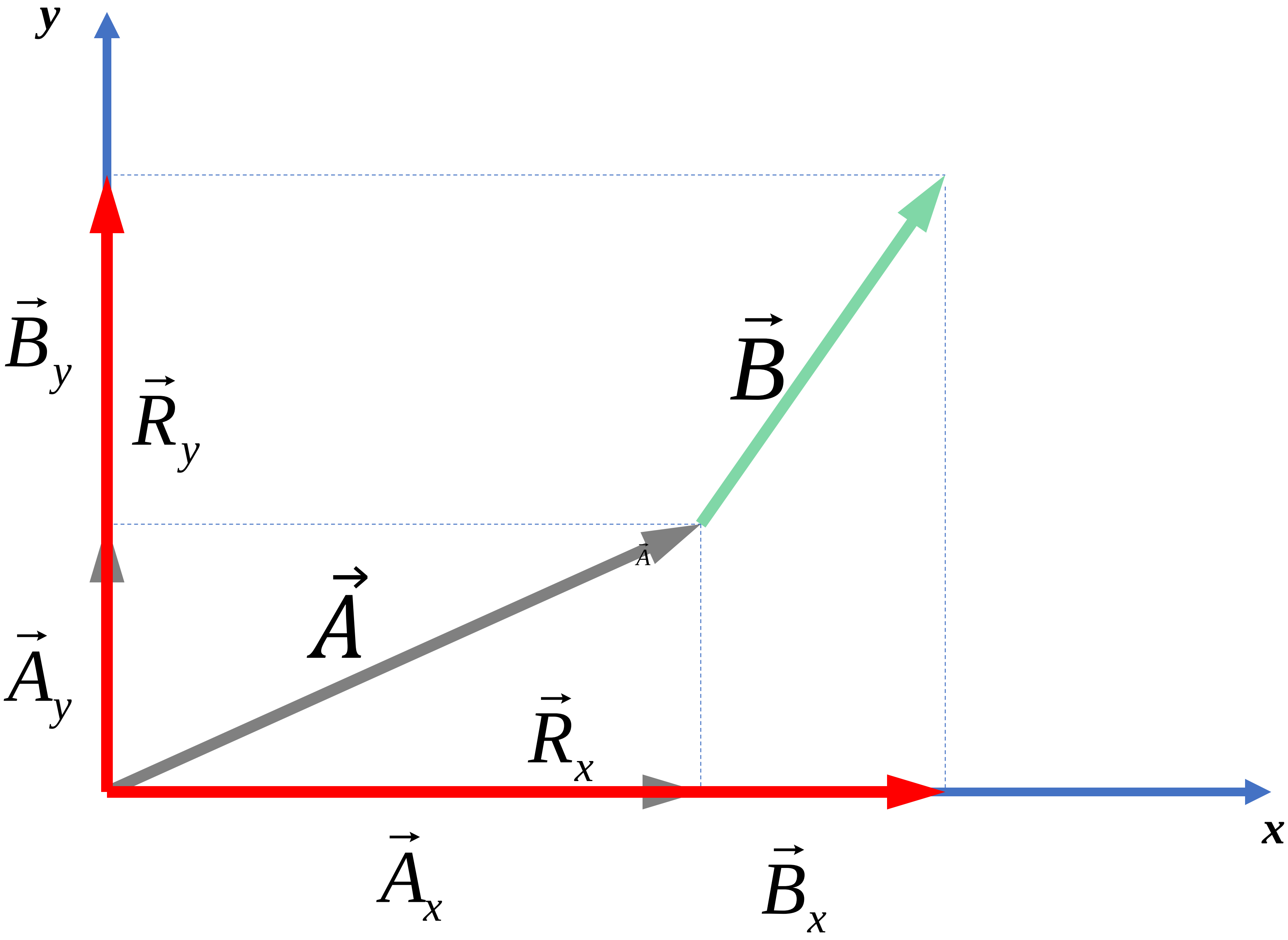
$$A = \sqrt{A_x^2 + A_y^2}$$

$$\tan\theta = \frac{A_y}{A_x}$$

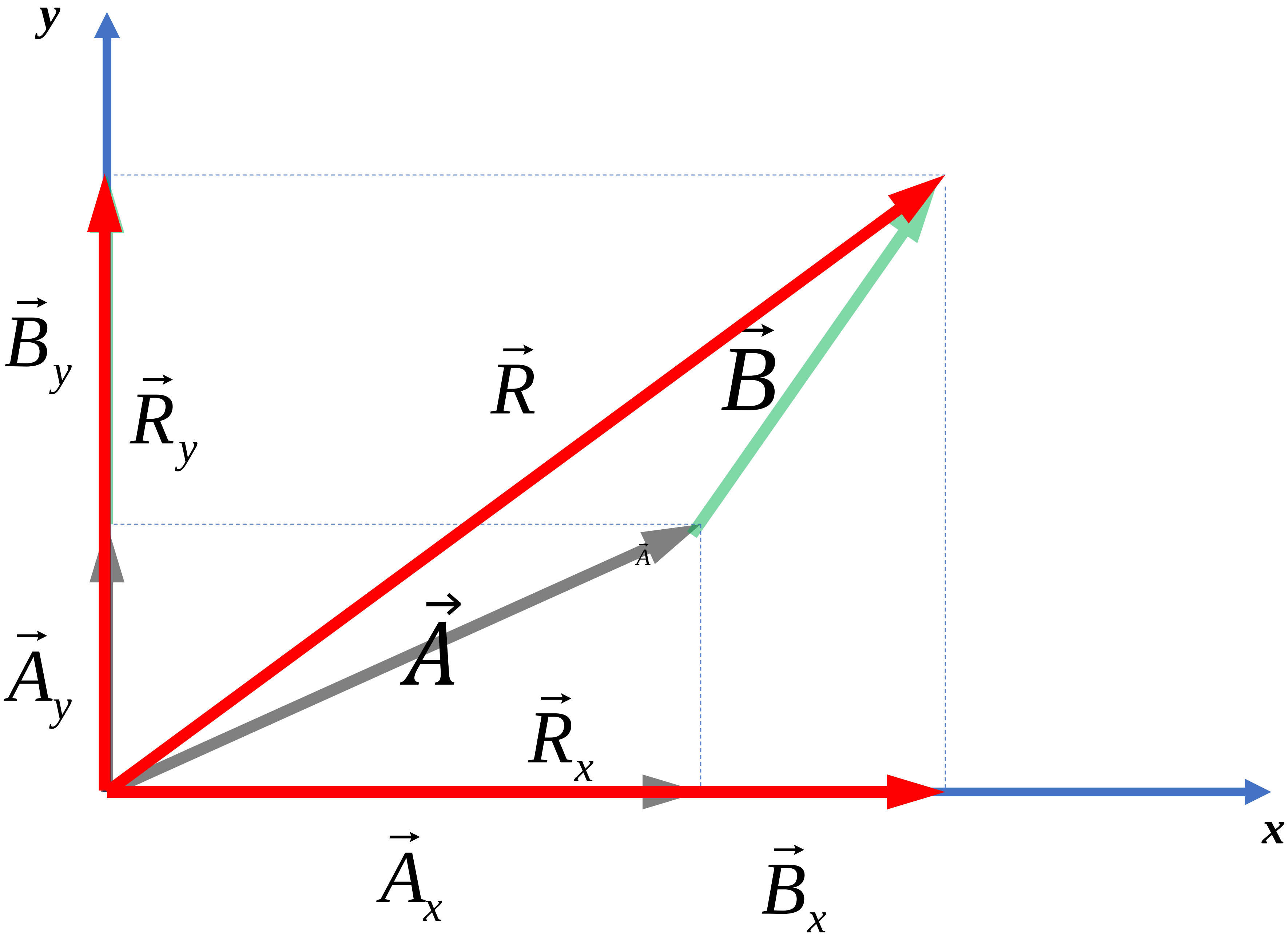
Example 3
Add the vectors shown



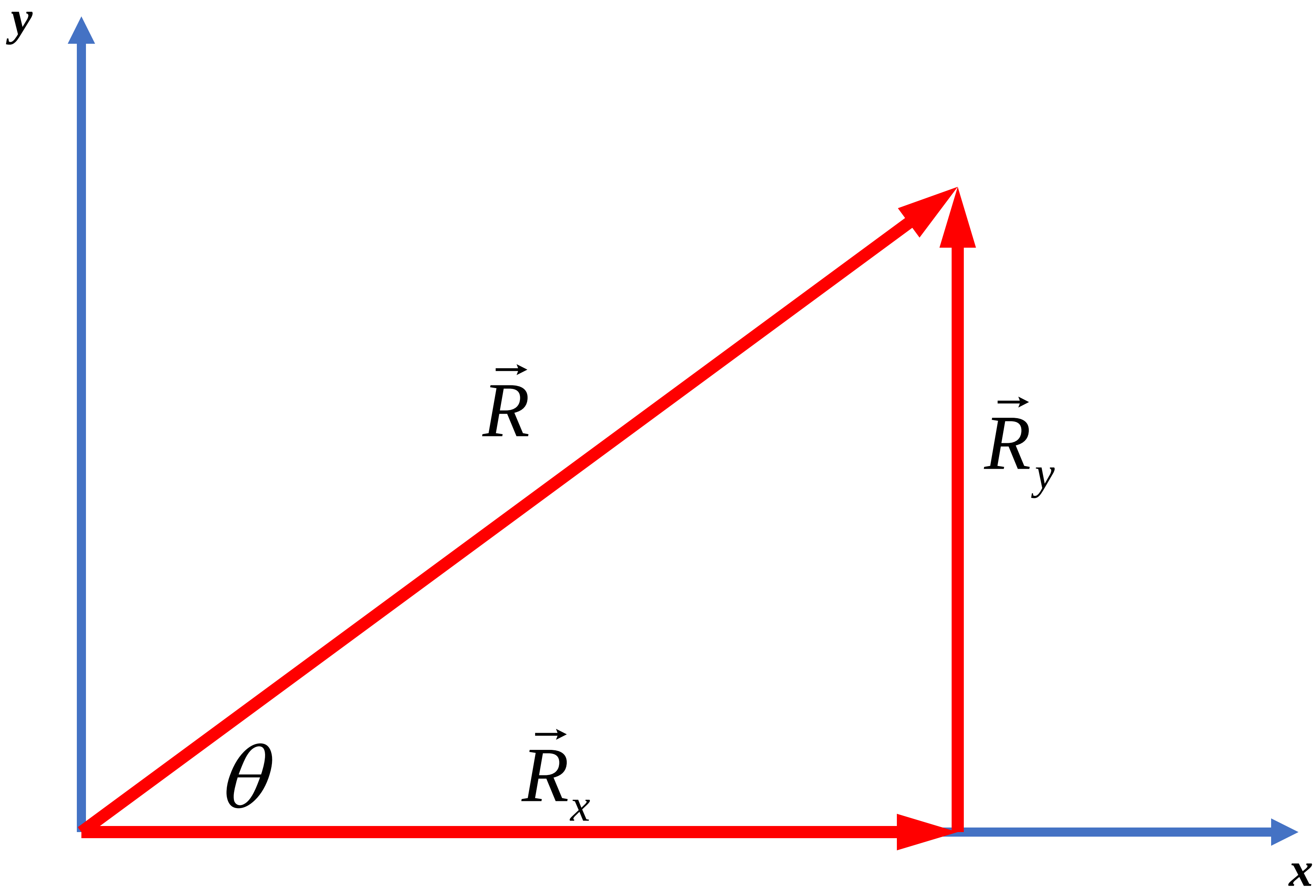

y
$\vec{B}_y$
$\vec{B}$
β
$\vec{A}$
$\vec{A}_y$
α
o
$\vec{A}_x$
$\vec{B}_x$
x

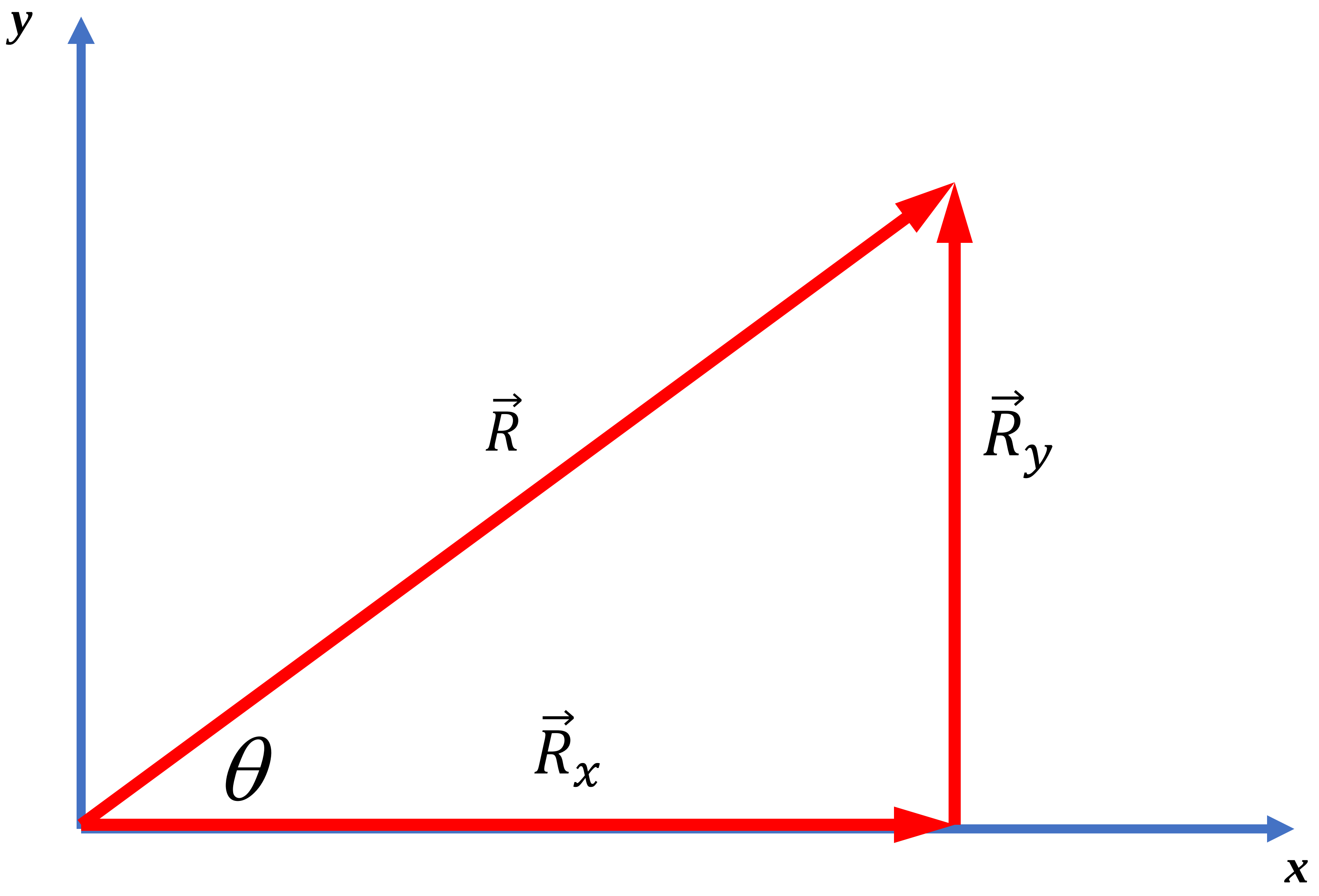


y
x
$\vec{B}_y$
$\vec{R}_y$
$\vec{B}$
$\vec{A}$
$\vec{A}$
$\vec{A}_y$
$\vec{R}_x$
$\vec{A}_x$
$\vec{B}_x$



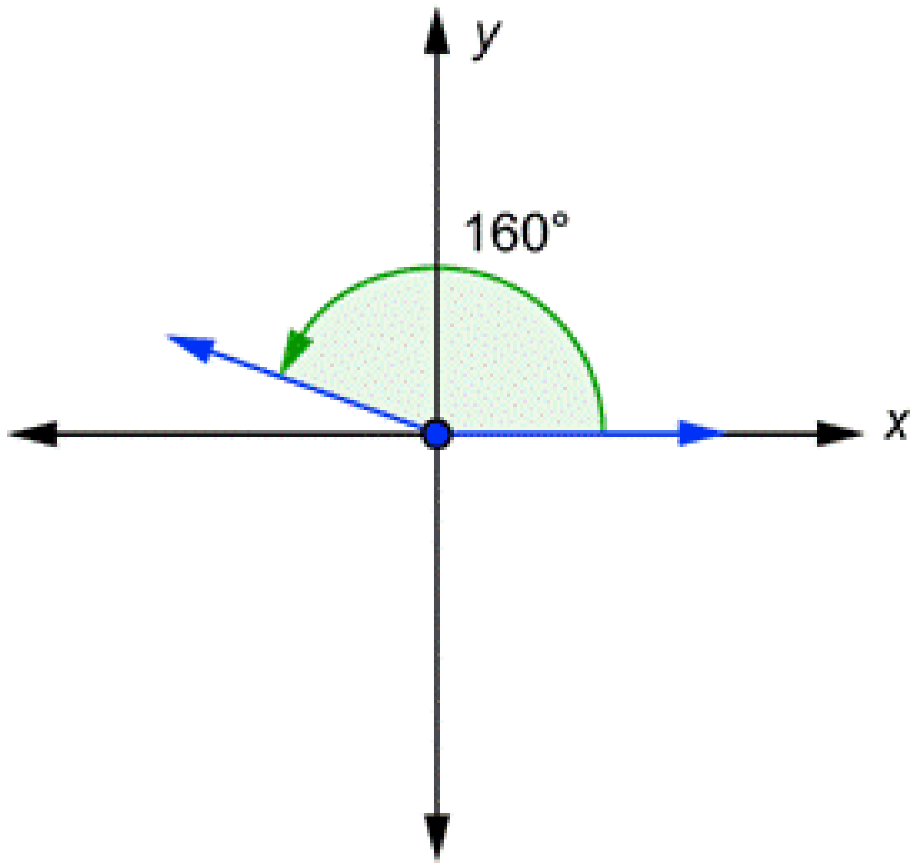
y
x
$\vec{B}_y$
$\vec{R}_y$
$\vec{R}$
$\vec{B}$
$\vec{A}$
$\vec{A}$
$\vec{A}_y$
$\vec{R}_x$
$\vec{A}_x$
$\vec{B}_x$


y
$\vec{R}$
$\vec{R}_y$
θ
$\vec{R}_x$
x


y
$\vec{R}$
$\vec{R}_y$
θ
$\vec{R}_x$
x

Algorithm for the Analytical Method

1. Resolve the vectors into perpendicular components.
2. Add the x-components of all vectors to get the x-component of the resultant R_x
3. Add the y-components of all vectors to get the y-component of the resultant R_y
4. Find the magnitude of the resultant
$$R = \sqrt{(R_x)^2 + (R_y)^2}$$
5. Find the direction of the resultant
$$\theta = \tan^{-1}\frac{R_y}{R_x}$$

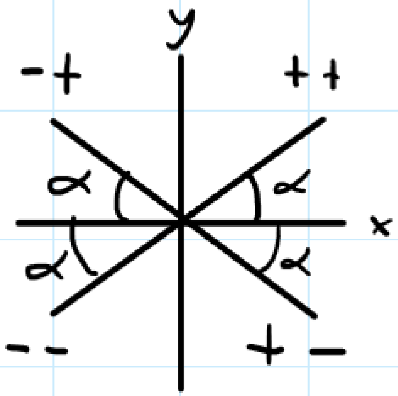


If you forget this, you lose a lot of marks

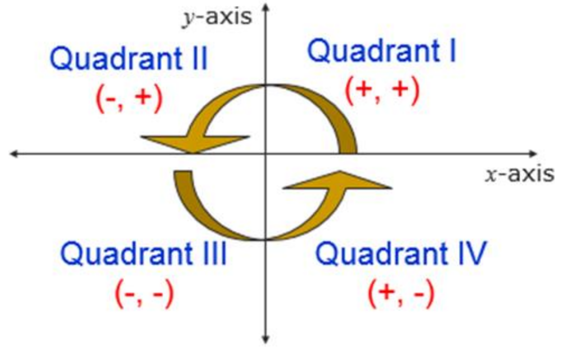
Angles are from the positive x axis rotating counterclockwise

Which quadrant is your resultant of x and y in?

	x	y
1	+	+
2	−	+
3	−	−
4	+	−

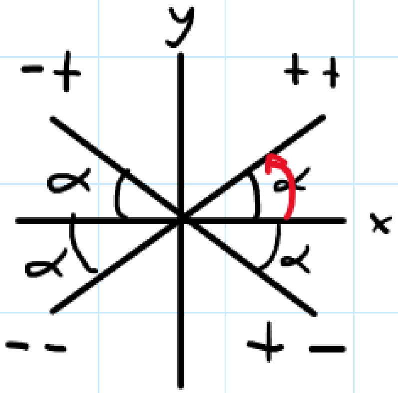


$$\alpha = \tan^{-1}\frac{|y|}{|x|}$$



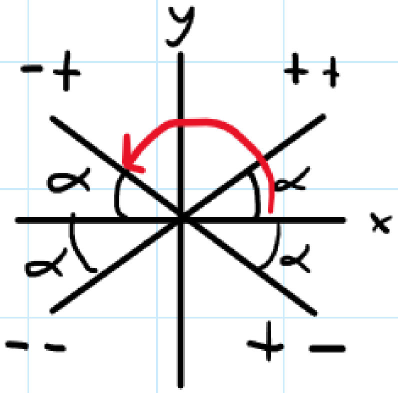
θ depends on quadrant

1



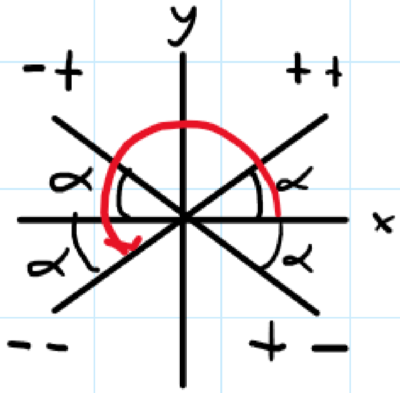
$\theta = \alpha$

2



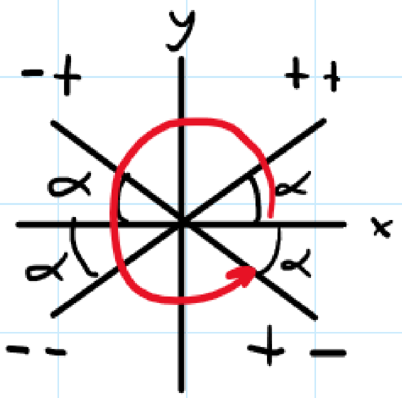
$\theta = 180 - \alpha$

3



$\theta = 180 + \alpha$

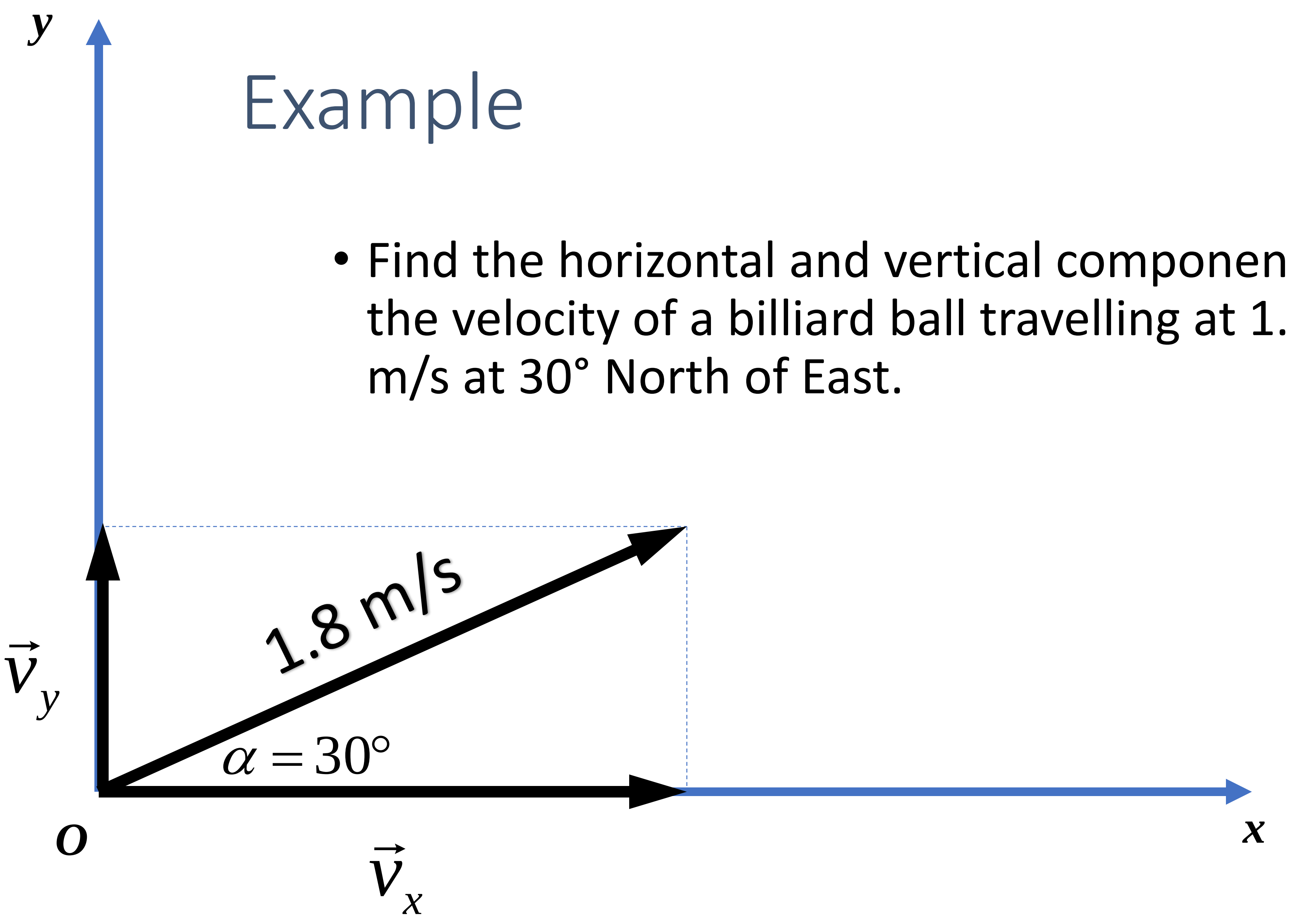
4



$\theta = 360 - \alpha$

Example

- Find the horizontal and vertical components of the velocity of a billiard ball travelling at 1.8 m/s at 30° North of East.

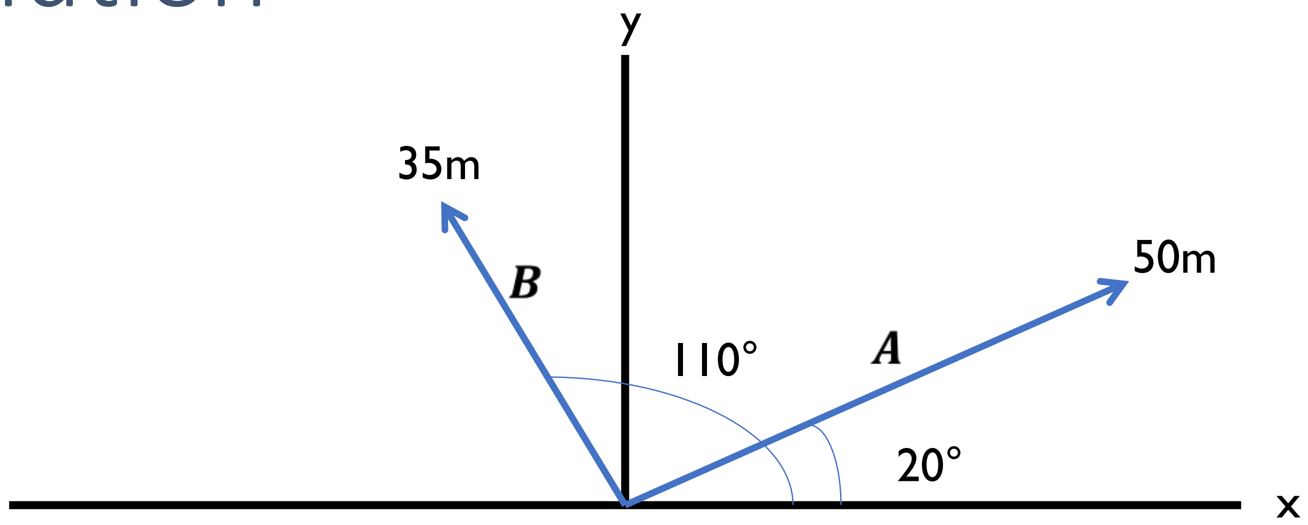


Example

Vector $\vec{A}$ has a magnitude of 50 m and a direction of 20°, and vector $\vec{B}$ has a magnitude of 35 m and a direction of 110°. Both angles are measured counterclockwise from the positive x-axis. Use components to calculate the magnitude and direction of the vector sum.

VTS Ex 1.7 is similar (30^o instead of 20^o)

Solution



First we draw a diagram to represent the vectors we are going to add together, like the one above.

We now 'resolve' the vectors into their respective components:

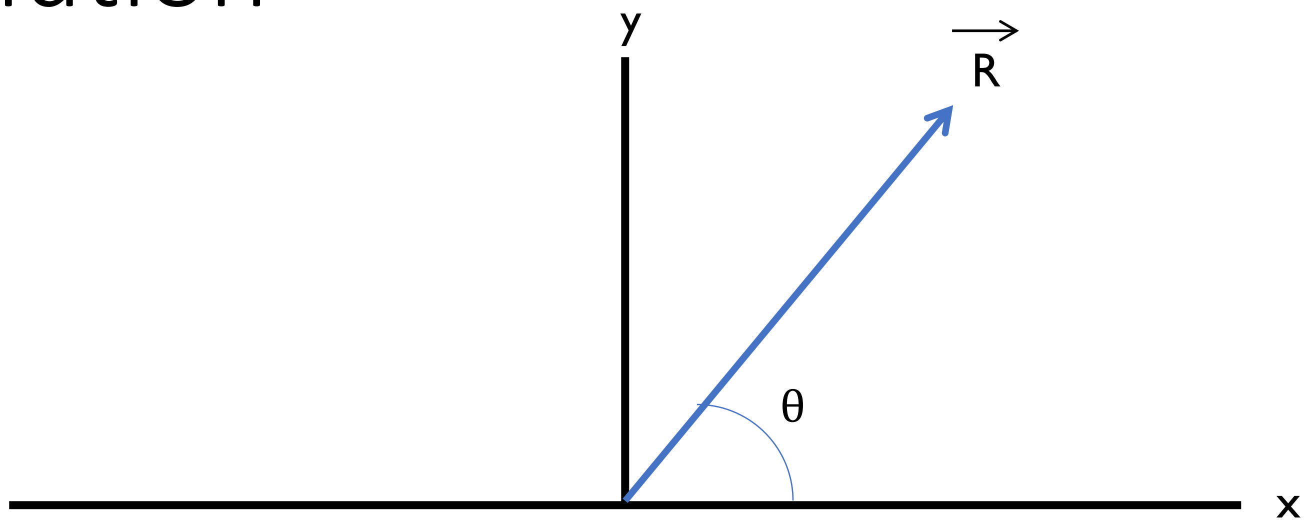
	X-Components:	Y-Components:
For Vector A:	50 cos 20° = 46.98 (2dp)	50 sin 20° = 17.10 (2dp)
For Vector B:	35 cos 110° = -11.97 (2dp)	35 sin 110° = 32.89 (2dp)

We now Add the X-Components Together & Add the Y-Components Together

Total of X-Components = 46.98 + (-11.97) = 35.01

Total of Y-Components = 17.10 + (+32.89) = 49.99

Solution



Now we have an X and a Y-Coordinate (x,y) system,

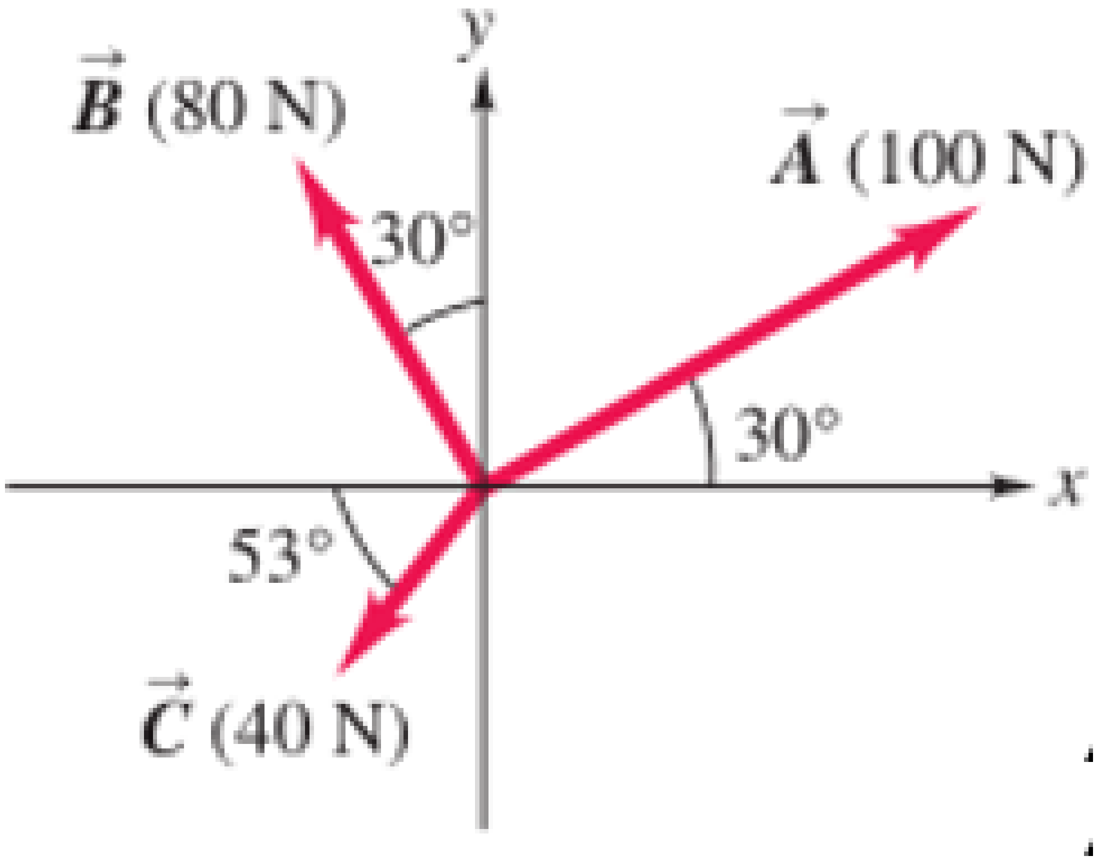
where x = 35.01 and y = 49.99.

We can now solve for R and θ, using our formulae.

$$\boldsymbol{R = \sqrt{x^2 + y^2} = \sqrt{35.01^2 + 49.99^2} = 61.03\ metres}$$

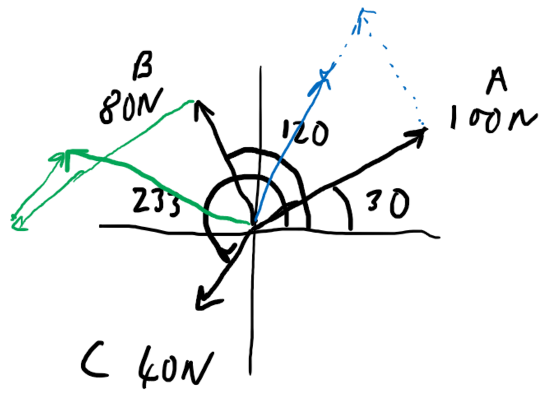
$$\boldsymbol{\theta = Tan^{-1}\left(\frac{y}{x}\right) = \left(\frac{49.99}{35.01}\right) = 54.99^{\circ}}$$

So our 2 vectors are resolved for the resultant vector $\vec{R}$



Add the 3 vectors shown in the diagram

(Also do B-A-C)



	X	Y
A	100 cos 30	100 sin 30
B	80 cos 120	80 sin 120
C	40 cos 233	40 sin 233
A+B+C	23	87
B-A-C	-103	51

$$R = \sqrt{23^2 + 87^2} = 90\,N$$

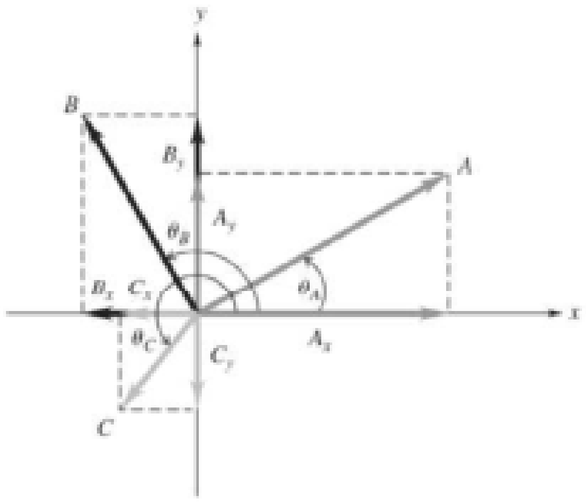
$$\alpha = \tan^{-1}\frac{87}{23} = 75^\circ = \theta$$

$$R = \sqrt{103^2 + 51^2} = 115\,N$$

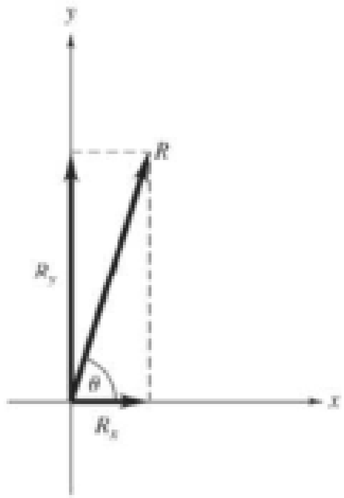
$$\alpha = \tan^{-1}\frac{51}{103} = 26$$

$$\theta = 180 - 26 = 154^\circ$$

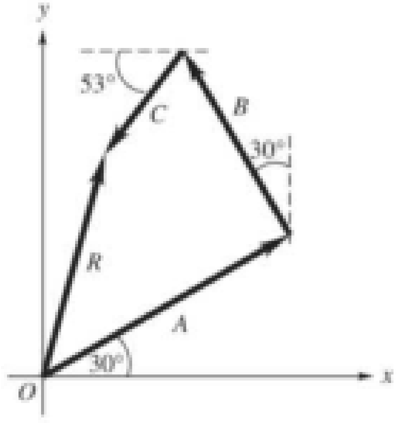
1.48. Set Up: The counterclockwise angles each vector makes with the $+x$ axis are: $\theta_A = 30^\circ$, $\theta_B = 120^\circ$, and $\theta_C = 233^\circ$. The components of each vector are shown in Figure (a) below.



(a)



(b)



(c)

Solve: (a) $A_x = A\cos 30^\circ = 87$ N; $A_y = A\sin 30^\circ = 50$ N; $B_x = B\cos 120^\circ = -40$ N; $B_y = B\sin 120^\circ = 69$ N; $C_x =$ $C\cos 233^\circ = -24$ N; $C_y = C\sin 233^\circ = -32$ N.

(b) $\vec{R} = \vec{A} + \vec{B} + \vec{C}$ is the resultant pull.

$$R_x = A_x + B_x + C_x = 87\text{ N} + (-40\text{ N}) + (-24\text{ N}) = +23\text{ N}$$
$$R_y = A_y + B_y + C_y = 50\text{ N} + 69\text{ N} + (-32\text{ N}) = +87\text{ N}$$

(c) R_x, R_y, and $\vec{R}$ are shown in Figure (b) above.

$$R = \sqrt{R_x^{\,2} + R_y^{\,2}} = 90\text{ N} \text{ and } \tan\theta = \frac{87\text{ N}}{23\text{ N}} \text{ so } \theta = 75^\circ$$

(d) The vector addition diagram is given in Figure (c) above. Careful measurement gives an $\vec{R}$ value that agrees with our results using components.

42. • A woman takes her dog Rover for a walk on a leash. To get the little pooch moving forward, she pulls on the leash with a force of 20.0 N at an angle of 37° above the horizontal. (a) How much force is tending to pull Rover forward? (b) How much force is tending to lift Rover off the ground?

49. • A disoriented physics professor drives 3.25 km north, then 4.75 km west, and then 1.50 km south. (a) Use components to find the magnitude and direction of the resultant displacement of this professor. (b) Check the reasonableness of your answer with a graphical sum.

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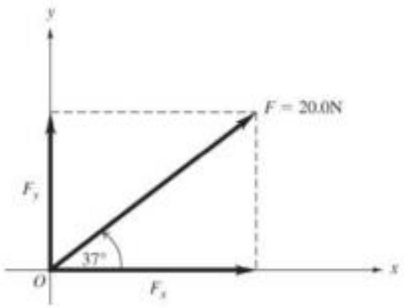
1.42. Set Up: Use coordinates for which the $+x$ axis is horizontal and the $+y$ direction is upward. The force $\vec{F}$ and its x and y components are shown in the figure below.



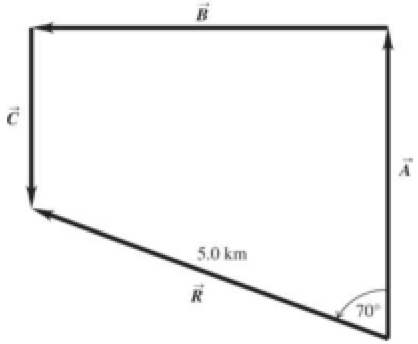
Solve: (a) $F_x = F(\cos 37^\circ) = (20.0\ \text{N})(\cos 37^\circ) = 16.0\ \text{N}$

(b) $F_y = F \sin 37^\circ = (20.0\ \text{N})(\sin 37^\circ) = 12.0\ \text{N}$

***1.49. Set Up:** Use coordinates for which $+x$ is east and $+y$ is north. Each of the professor's displacement vectors make an angle of 0° or 180° with one of these axes. The components of his total displacement can thus be calculated directly from $R_x = A_x + B_x + C_x$ and $R_y = A_y + B_y + C_y$.

Solve: (a) $R_x = A_x + B_x + C_x = 0 + (-4.75\ \text{km}) + 0 = -4.75\ \text{km} = 4.75\ \text{km west}$; $R_y = A_y + B_y + C_y = 3.25\ \text{km} + 0 + (-1.50\ \text{km}) = 1.75\ \text{km} = 1.75\ \text{km north}$; $R = \sqrt{R_x^2 + R_y^2} = 5.06\ \text{km}$; $\theta = \tan^{-1}(R_y/R_x) = \tan^{-1}[(+1.75)/(-4.75)] = -20.2^\circ$; $\phi = 180^\circ - 20.2^\circ = 69.8^\circ$ west of north

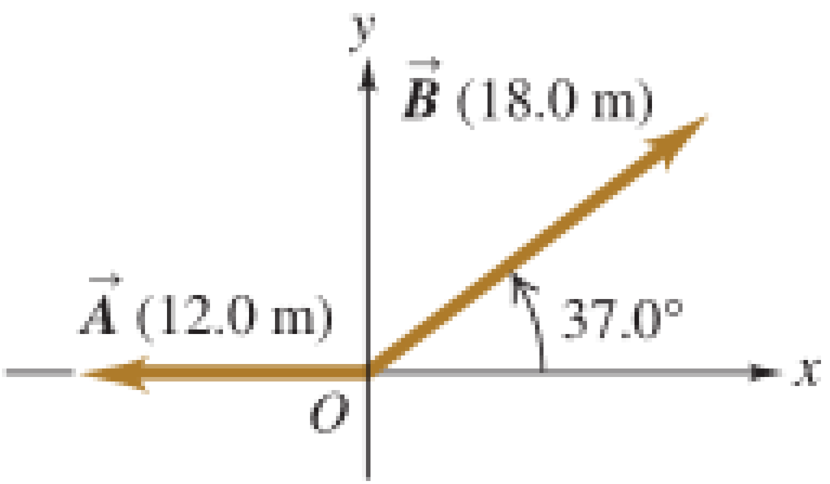
(b) From the scaled sketch in the figure below, the graphical sum agrees with the calculated values.



Reflect: The magnitude of his resultant displacement is very different from the distance he traveled, which is 159.50 km.

DO BOTH GRAPHICAL and ANALYTICALLY

37. • For the vectors $\vec{A}$ and $\vec{B}$ shown in Figure 1.22, carefully sketch (a) the vector sum $\vec{A} + \vec{B}$; (b) the vector difference $\vec{A} - \vec{B}$; (c) the vector $-\vec{A} - \vec{B}$; (d) the vector difference $\vec{B} - \vec{A}$.

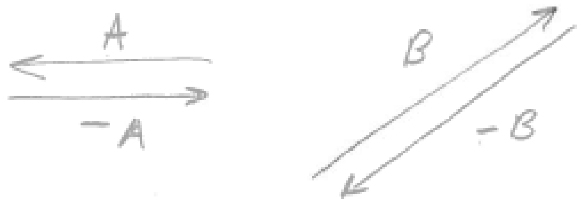


	X	Y	
A	$12\cos 180$ (-12)	$12\sin 180$ (0)	
B	$18\cos 37$ (14.4)	$18\sin 37$ (10.8)	
A+B	2.4	10.8	a)
A−B	-26.4	-10.8	b)
−A−B	-2.4	-10.8	c)
B−A	26.4	10.8	d)

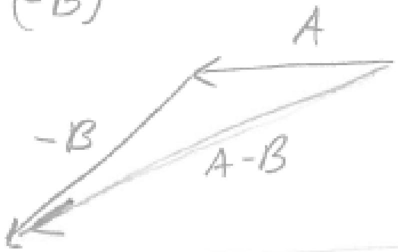
b) $R = \sqrt{26.4^2 + 10.8^2} = 28.5$

$\alpha = \tan^{-1} \dfrac{10.8}{26.4} = 22^\circ$

$\theta = 180 + 22 = 202^\circ$



$A - B = A + (-B)$

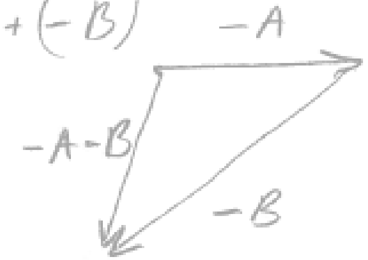


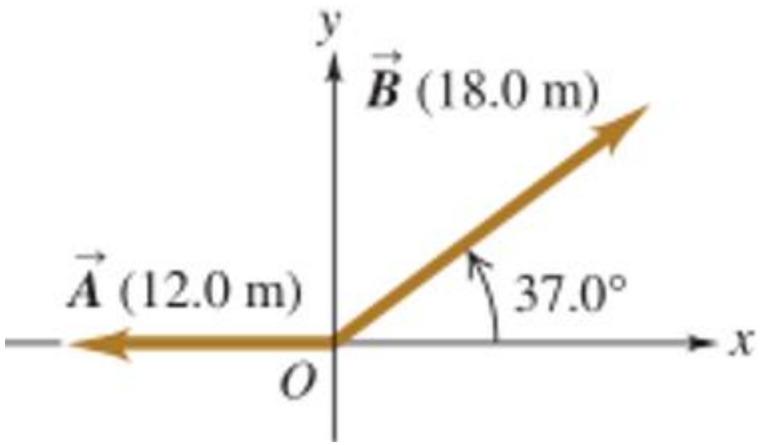
c) $R = \sqrt{2.4^2 + 10.8^2} = 11.1$

$\alpha = \tan^{-1} \dfrac{10.8}{2.4} = 77^\circ$

$\theta = 180 + 77 = 257^\circ$

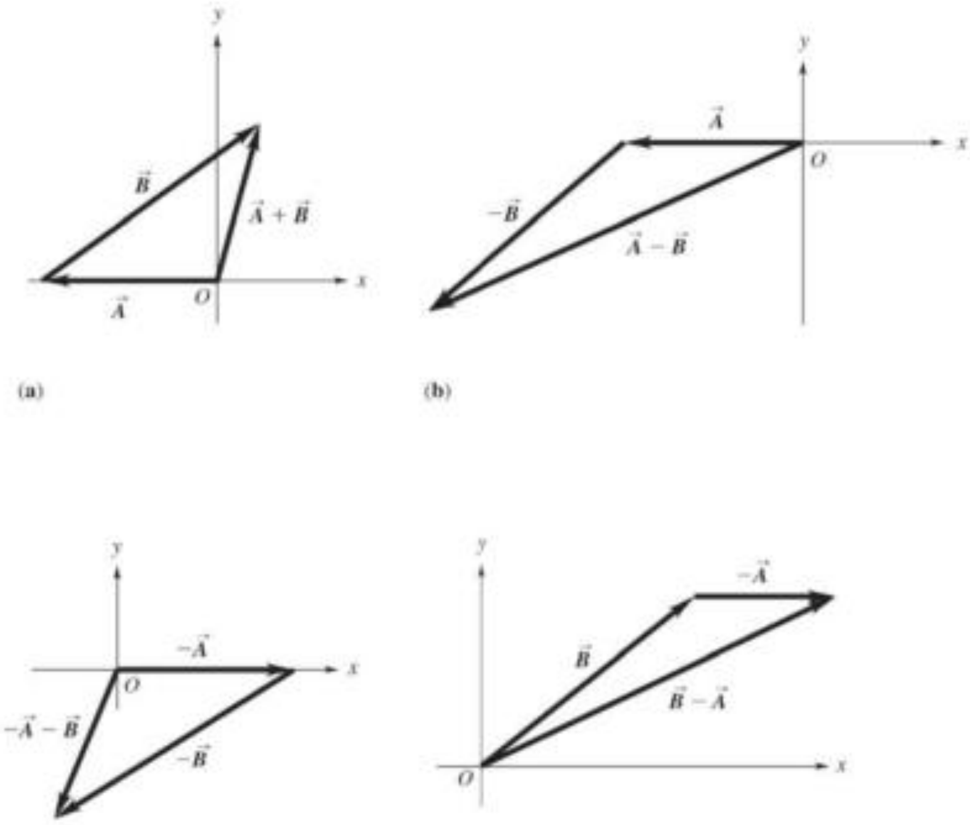
$(-A) + (-B)$





1.37. Set Up: Draw the vectors to scale on graph paper, using the tip to tail addition method. For part (a), simply draw $\vec{B}$ so that its tail lies at the tip of $\vec{A}$. Then draw the vector $\vec{R}$ from the tail of $\vec{A}$ to the tip of $\vec{B}$. For (b), add $-\vec{B}$ to $\vec{A}$ by drawing $-\vec{B}$ in the opposite direction to $\vec{B}$. For (c), add $-\vec{A}$ to $-\vec{B}$. For (d), add $-\vec{A}$ to $\vec{B}$.

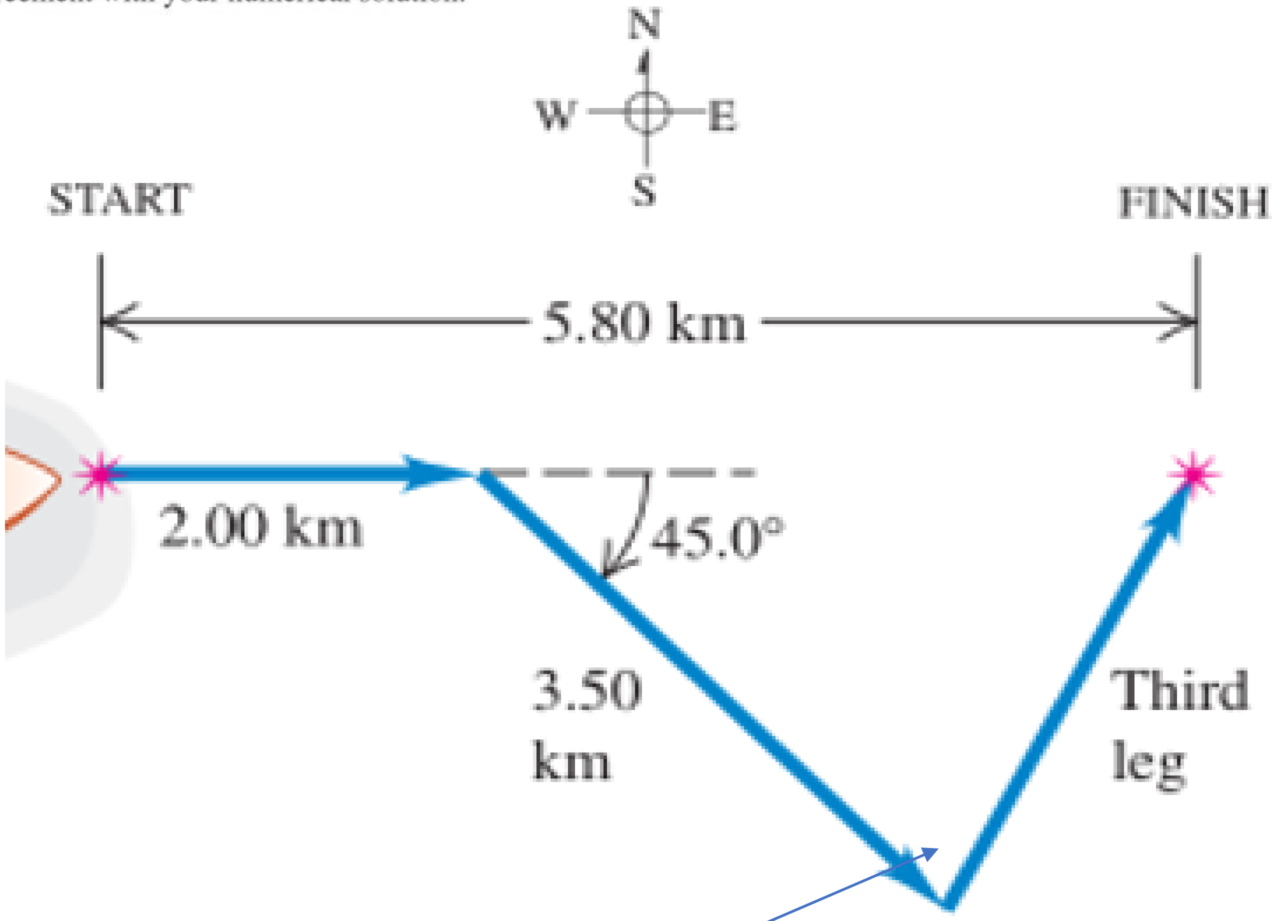
Solve: The vector sums and differences are shown in the figures below.



(a) (b) (c) (d)

Thinking problem

62. •• A sailor in a small sailboat encounters shifting winds. She sails 2.00 km east, then 3.50 km southeast, and then an additional distance in an unknown direction. Her final position is 5.80 km directly east of her starting point. (See Figure 1.28.) Find the magnitude and direction of the third leg of the journey. Draw the vector addition diagram, and show that it is in qualitative agreement with your numerical solution.



Not a right angle

Summary

Basics (CLO1, chapter 1)

- SOH CAH TOA
- Units m kg s
- Significant figures (x or /) use least significant

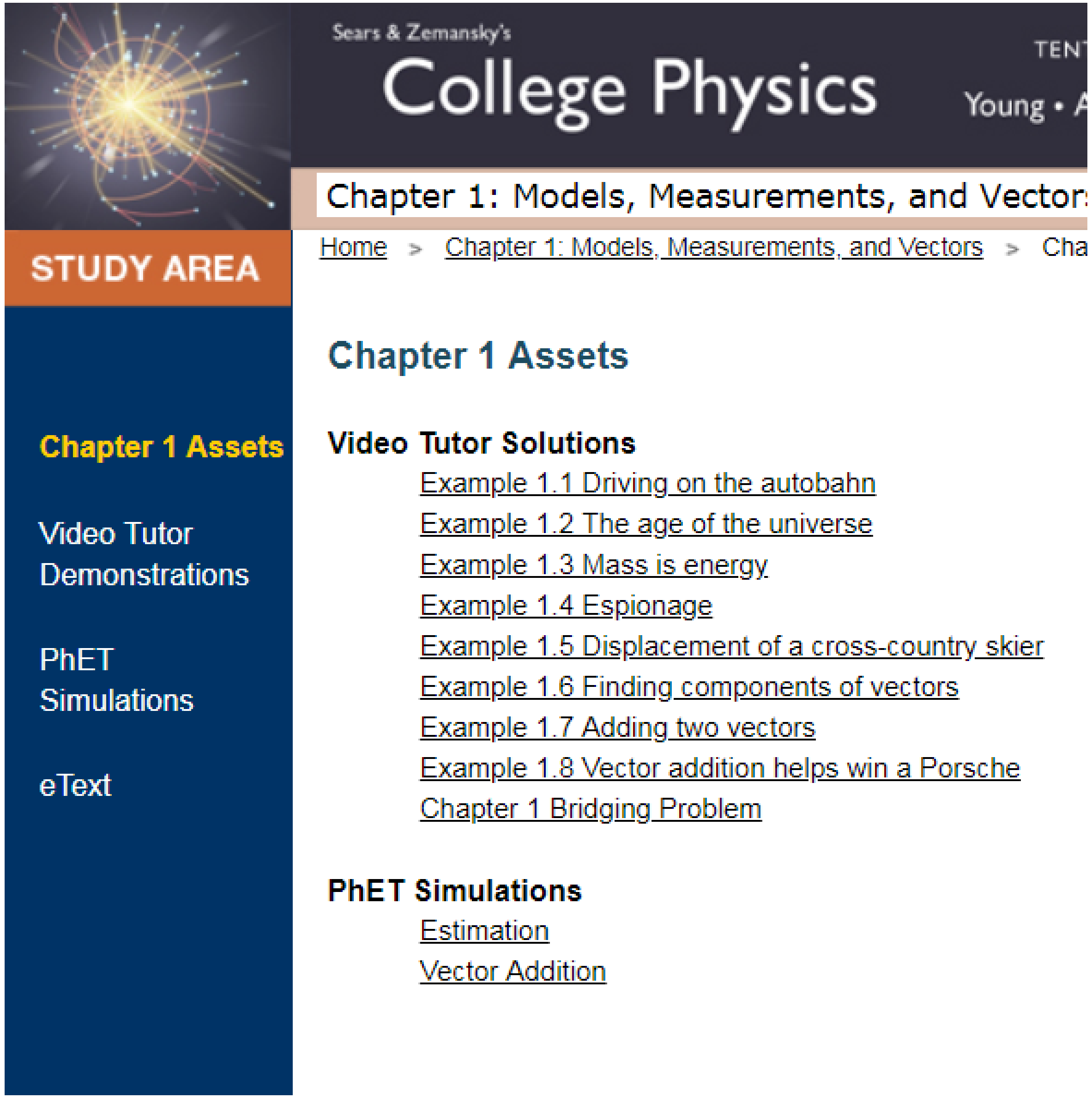
Vectors (CLO2, chapter 1)

- We take the angle from the positive x axis moving counterclockwise.
- We quote our final angle from the positive x axis moving counterclockwise.
- DIRECTION is important for vectors
- If you need to define velocity you need to define both magnitude and direction as it is a vector.

VTS Ex 1.1

PhET Estimation

Use the textbook for more details



Appendix

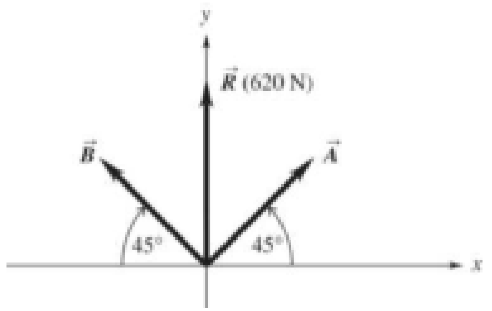
Extra info for interest
More examples

Quality	Unit	New (fundamental constants)	date
Time	s	The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom.	1997
Length	m	The meter is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second. (based on c = 299 792 458 m s−1 exactly)	1983
Mass	kg	The kilogram (kg) is defined by taking the fixed numerical value of the Planck constant h to be 6.626,070,150 × 10^{-34} when expressed in the unit J s, which is equal to kg m^2 s^1, where the meter and the second are defined in terms of c and Δv.	2019
Current	A	The ampere (A) is defined by taking the fixed numerical value of the elementary charge e to be 1.602,176,634 × 10^{-19} when expressed in coulombs, which is equal to A s, where the second is defined in terms of Δv.	2019
Temperature	K	The kelvin (K) is defined by taking the fixed numerical value of the Boltzmann constant k to be 1.380,649 × 10^{-23} when expressed in the unit J K^1, which is equal to kg m^2 s^{-2} K^1, where the kilogram, meter and second are defined in terms of h, c and Δv.	2019
Luminosity	cd	The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 1012 hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.	1979
Amount	mol	The mole (mol) contains exactly 6.022,140,76 × 10^{23} elementary entities. This number is the fixed numerical value of the Avogadro constant, NA, when expressed in the unit mol^{-1} and is called the Avogadro number.	2019

47. ●● You're hanging from a chinning bar, with your arms at right angles to each other. The magnitudes of the forces exerted by both your arms are the same, and together they exert just enough upward force to support your weight, 620 N. (a) Sketch the two force vectors for your arms, along with their resultant, and (b) use components to find the magnitude of each of the two "arm" force vectors.

***1.47. Set Up:** We know that the two force vectors, $\vec{A}$ and $\vec{B}$, have the same magnitude ($A = B$) and form a right angle; thus, the two forces and their resultant form an isosceles right triangle. Use coordinates for which the resultant force is parallel to the $+y$-direction and find the magnitude of A and B by setting the y-component of the resultant equal to 620 N.

Solve: (a) The two forces and their resultant are shown below.



(b) $R_y = A_y + B_y = A\sin 45^\circ + B\sin 135^\circ = 2A\sin 45^\circ = 620\text{ N}$. Thus, $A = \dfrac{620\text{ N}}{2\sin 45^\circ} = 440\text{ N}$.

Reflect: Note that $R_x = A_x + B_x = A\cos 45^\circ + B\cos 135^\circ = 0$.