11th Physics 1 Motion 2019-20

Orientation

1. Seating
2. Absence and Tardiness: A student arriving after chime will be marked **tardy**.
   A student arriving to or leaving class more than 20 minutes will be marked **absent**.
3. Local Rule: *No scribbles on desks (BVS!), *No chewing gum, *Use your own **calculator**(**x smartphone**).
4. Textbook and Packets
5. Physics Website www.tmoritani.com/KNY-Physics (ID: keio, PW: wakakichi)
6. Tests: 2 mini-tests/Q + Exam; Past tests with solutions
7. Labs and Lab Reports "How to write." Senpai's reports.
8. Grade: Tests 55%, Labs 35%, Class 10%
9. Schedule (Class and Tests) on the website
10. Preparation and Review
11. Extra help: Morning ( ) and after class
12. Exchanging Classes

Yearly Schedule

Quarter	Chapter	Walker "Physics	Test
I	1	Introduction to Physics	1Q-#1
	2	Introduction to Motion	1Q-#1
	3	Acceleration and Accelerated Motion	1Q-#1
	4	Motion in Two Dimensions	1Q-#2
		Force	1Q-Ex
	12	Gases, Liquids, and Solids	1Q-Ex
II	5	Newton's Laws of Motion	2Q-#1
	6	Work and Energy	2Q-#1, #2
	10	Temperature and Heat	2Q-#2
III	19	Electric Charges and Forces	3Q-#1
	20	Electric Fields and Electric Energy	3Q-#1
	21	Electric Current and Electric Circuits	3Q-#1
	22	Magnetism and Magnetic Fields	3Q-#2
	23	Electromagnetic Induction	3Q-#2
IV	13	Oscillations and Waves	4Q-#1
	14	Sound	4Q-#1
	15	The Properties of Light	4Q-#2
	17	Refraction and Lenses	4Q-#2
	18	Interference and Diffraction	4Q-Ex

A. Reading numbers and equations in English

1		10^3 10^6 10^9 10^{12} 10^4	10^3 thousand, 10^6 million, 10^9 billion, 10^{12} trillion, 10^4 ten thousand
2	Decimal	3.45	three point four five
3	Fraction	$\frac{1}{2}$ $\frac{1}{3}$ $\frac{2}{3}$ $\frac{3}{10}$ $1\frac{1}{2}$ $\frac{3}{4}$	$\frac{1}{2}$ a half, one half $\frac{1}{3}$ a third, one third $\frac{2}{3}$ two thirds $\frac{3}{10}$ three tenths $1\frac{1}{2}$ one and a half $\frac{3}{4}$ three fourths
4	Addition	$12 + 5 = 17$	• Twelve plus five equals seventeen. • Twelve plus five makes seventeen • The sum (total) of 12 and 5 is 17.
5	Subtraction	$12 – 5 = 7$	• 12 minus 5 equals (is) 7. • Subtract 5 from 12, the answer is (yields) 7.
6		$98 – 7 + 2 = ?$	• Subtract 7 from 98 and add 2, what is the result?
7	Multiplication	20 x 3 = 60	• Twenty multiplied by 3 equals 60. • Twenty <u>times</u> 3 is 60. • Multiply 20 by 3 to get 60.
8	Division	$20 \div 2 = 10$	• 20 <u>divided by</u> 2 equals (is, makes) 10. • Half of 20 is 10.
9		$21 \div 3 = 7$	• 21 divided by 3 gives 7. • One-third of 21 is 7.
10		$\times 2$ $\times 10$	$\times 2$ two fold, two times, two x, power of two, double $\times 10$ ten-fold, ten times, power of ten
11	Root	$\sqrt{a}$ $\sqrt[3]{a}$ $\sqrt[n]{a}$	$\sqrt{a}$ square root of a $\sqrt[3]{a}$ cube root of a $\sqrt[n]{a}$ n-th root of a
12	Exponent	x^2 x^3 x^4	x^2 x squared x^3 x cubed x^4 x <u>to the fourth</u> x (raised) to the fourth (power)
13		x^{-2} $x^{\frac{1}{3}}$	x^{-2} x to the minus two (power) $x^{\frac{1}{3}}$ x to the one-third (power)
14		10^0 10^x	10^0 ten to the zero power 10^x ten to the x-th (power)
15	Rounding	$20 \div 2.2 = 9.09 \rightarrow 9.1$	Twenty divided by two point two is nine point 0 nine; it is nine point one when rounding (off).
16	Equations	$kx_i = \int x \, dm$	k times x sub i equals the integral of x dm.

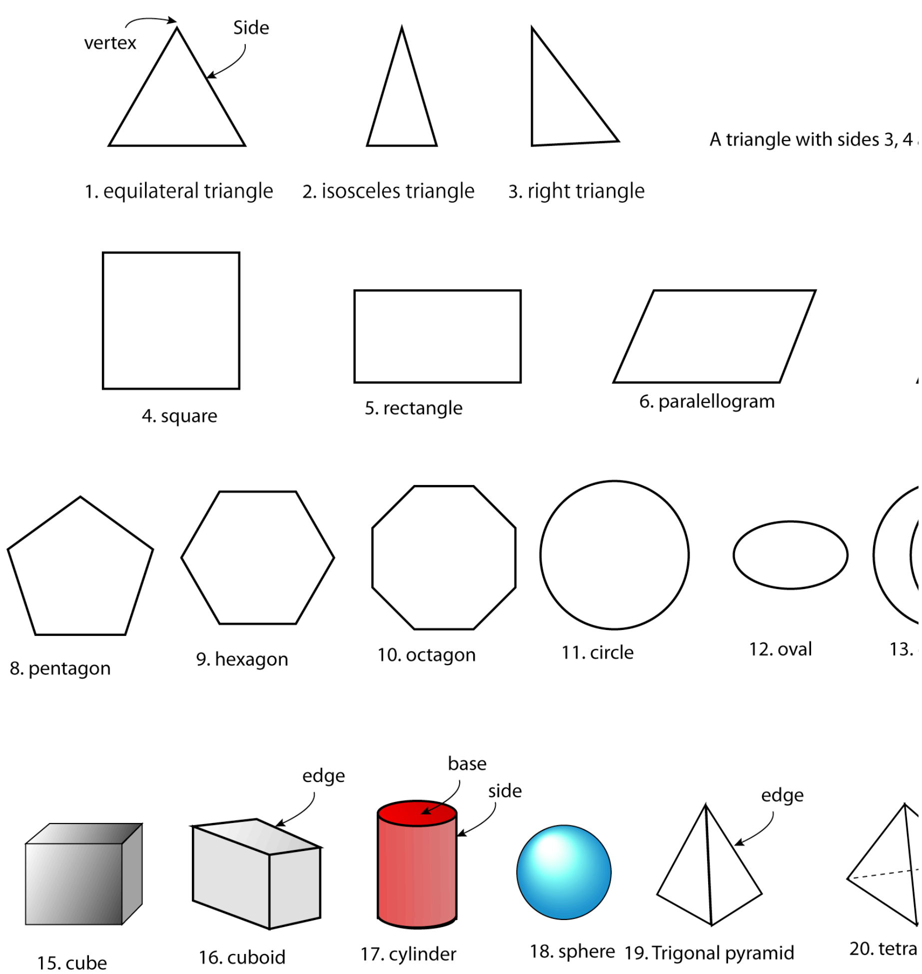
- We increased output <u>by a factor of</u> five.
- If the mass of a weight is doubled in a simple spring, <u>by what factor does</u> the period <u>change</u>?
- <u>By what factor does</u> the kinetic energy of a car <u>change</u> when its speed id tripled?
-
- This rope is <u>three times longer</u> than that one. = This rope is three times as long as that one.
- <u>How many times heavier</u> is an elephant than a mouse?

B. Common Prefixes

Power	Prefix	Abbreviation
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P

Power	Prefix	Abbreviation
10^{-2}	centi	c
10^{-3}	mili	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

C. Geometrical figures



title, legend

column titles

table body, data

D. Tables

footnotes

Table 4. Population variation in hatch success (mean percent) of unfertilized eggs for females from populations sampled in 1997. N = number of females tested.

Population	Mean (%)	Standard deviation	Range	N
Beaver Creek [T]	7.31	13.95	0 – 53.16	15
Honey Creek [T]	4.33	7.83	0 – 25.47	11
Cedar Creek [P]	6.56	9.64	0 – 46.52	64
Little Dixie Lake [L]	7.96	14.54	0 – 67.66	71
Whelstone Lake [L]	7.36	12.93	0 – 63.38	57

[T] = temporary stream, [P] = permanent streams, [L] = lakes.

E. Graphs

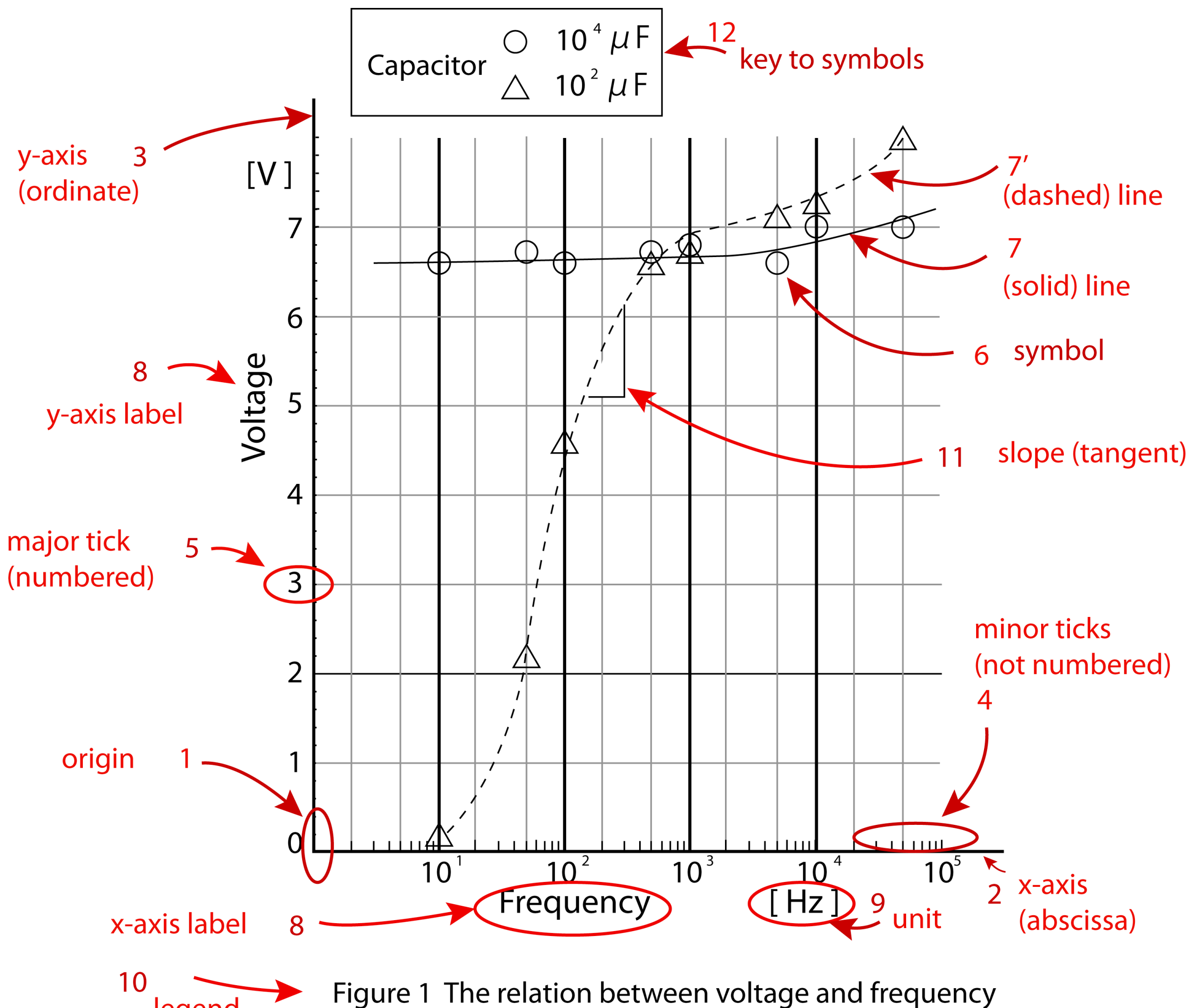


Figure 1 The relation between voltage and frequency

3. Units of Length, Mass, and Time

[Q2] Length [L]

meter (m)

[Q3] Mass [M]

kilogram (kg)

[Q4] Time [T]

second (s)

TABLE 1–1 Typical Distances

Distance from Earth to the nearest large galaxy (the Andromeda galaxy, M31)	2×10^{22} m
Diameter of our galaxy (the Milky Way)	8×10^{20} m
Distance from Earth to the nearest star (other than the Sun)	4×10^{16} m
One light-year	9.46×10^{15} m
Average radius of Pluto's orbit	6×10^{12} m
Distance from Earth to the Sun	1.5×10^{11} m
Radius of Earth	6.37×10^{6} m
Length of a football field	10^{2} m
Height of a person	2 m
Diameter of a CD	0.12 m
Diameter of the aorta	0.018 m
Diameter of a period in a sentence	5×10^{-4} m
Diameter of a red blood cell	8×10^{-6} m
Diameter of the hydrogen atom	10^{-10} m
Diameter of a proton	2×10^{-15} m

TABLE 1–2 Typical Masses

Galaxy (Milky Way)	4×10^{41} kg
Sun	2×10^{30} kg
Earth	5.97×10^{24} kg
Space shuttle	2×10^{6} kg
Elephant	5400 kg
Automobile	1200 kg
Human	70 kg
Baseball	0.15 kg
Honeybee	1.5×10^{-4} kg
Red blood cell	10^{-13} kg
Bacterium	10^{-15} kg
Hydrogen atom	1.67×10^{-27} kg
Electron	9.11×10^{-31} kg

TABLE 1–3 Typical Times

Age of the universe	5×10^{17} s
Age of the Earth	1.3×10^{17} s
Existence of human species	6×10^{13} s
Human lifetime	2×10^{9} s
One year	3×10^{7} s
One day	8.6×10^{4} s
Time between heartbeats	0.8 s
Human reaction time	0.1 s
One cycle of a high-pitched sound wave	5×10^{-5} s
One cycle of an AM radio wave	10^{-6} s
One cycle of a visible light wave	2×10^{-15} s

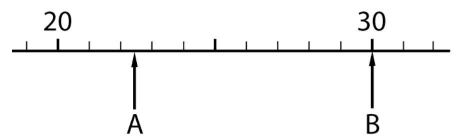
[Q5] A minivan sells for 33,200 dollars. Express the price in kilodollars and megadollars.

[Q6] A typical E.coli bacterium is about 5 micrometers (or microns) in length. Give this length in millimeters and kilometers.

4. Significant Figures (W p24-29)

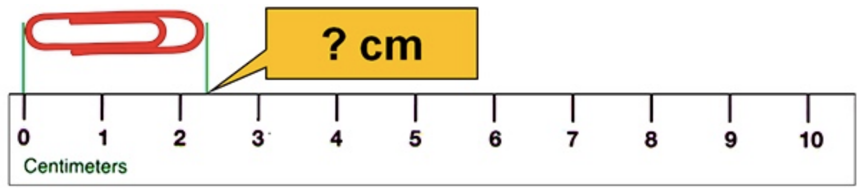
1. Measurement always includes some **uncertainty**. = Observed values always include some uncertainty.
(This is the basic standpoint in science.)

[Q1] What are the values, A and B shown?

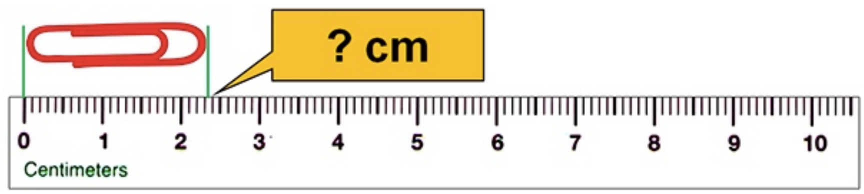


A =
B =

[Q2] What is the length of the clip?



[Q3] What is the length of the clip?



[Rule-1] In a measurement, we must read the digits that are determined by marks of a device and additionally estimate one more digit. The digits are all significant figures.

2. **The number of significant figures**

[Q2] How many significant figures are there in the following numbers?:

[Example] 123 --- It has three significant figures
(a) 0.000054 ---
(b) 3.001×10^5 ---
(c) 2.70 ---
(d) 2700 …
(e) 0.002700 …

[Rule-2] a) All non-zero numbers are significant
b) Zeros between non-zero numbers are significant
c) Leading zeros before a number are not significant.
d) Trailing zeros after a number are uncertain whether they are significant or not unless there's a decimal point.
Compare: 250 250. 250.0 250.00

3. **[Rule-3] Scientific notation** specifies the number of significant figures

[Q3-1]
0.0316 →
31.60 →
316.0 →
3160 →
2900 →
2900.0 →

[Q3-2] Write the numbers at the right using scientific notation.

[Q3-3] Find the product of the mass of Earth and the mass of a hydrogen atom.

[Q3-4] Divide the mass of hydrogen atom by the mass of Earth.

(14-a) 5970000000000000000000000 kg (the mass of the Earth) (14-b) 0.00000000000000000000000000167 kg (the mass of hydrogen atom)

4. **[Rule-4] <u>Multiplication and Division</u> --- The quantity with <u>the fewest significant figures</u> in input determines the number of significant figures in the answer.**

Example: $\frac{123.45 \times 0.0555}{22.20} = 0.30862500 \rightarrow 0.309$ (Rounding)

5. **Rounding (or Rounding-off)**

[Q5-1] Round the followings to three significant digits:

1) 23.47 →
2) 23.429 →
3) 23.449 →
4) 23.451 →
5) 23.45 →
6) 23.55 →
7) 23.450 →
8) 23.4501→

[Rule-5] Rounding

a) **Round down if the digit flowing the last significant figure is a 0,1,2,3 or 4.**
b) Round up if the digit flowing the last significant figure is a6,7,8 or 9.
c) Round <u>up</u> if the digit following the last significant figure is a 5 followed by a nonzero digit.
   54.8511 → 54.9 54.8501 → 54.9
d) **Round <u>down</u> if the last significant figure is an <u>even</u> number and the next digit is a 5, with no other nonzero digits. 54.85 → 54.8 54.85000 → 54.8**
e) Round <u>up</u> if the last significant figure is an <u>odd</u> number and the next digit is a 5, with no other nonzero digits.
   54.75 → 54.8 54.75000 → 54.8

[Q5-2] Find the number of significant figures of the following quantities:

a) 5 h 23 min
b) 1 h 23 min
c) 1 h 23 min 11 s
d) 3 h 23 min 11 s
e) 5’ 5”

[5-3] Find the solutions:

a) 5.0 m x 5.0 m =
b) 5 m x 5 m =
c) 5 students x 5 biscuits/student =

6. **[Rule-6]** **<u>Addition and Subtraction</u> --- The result is limited by the number with the largest uncertain decimal position in input.**

Example:

$$\begin{array}{r} 123.4500 \\ 12.20 \\ +)\ 0.0063 \\ \hline 135.6\cancel{563} \rightarrow 135.66 \\ 6 \end{array}$$

[Q6-1]

$$\begin{array}{r} 17.3 \\ +)\ 0.48 \\ \hline \end{array} \qquad \begin{array}{r} 0.039 \\ +)\ 2.66 \\ \hline \end{array} \qquad \begin{array}{r} 5.361 \\ -)\ 2.5 \\ \hline \end{array}$$

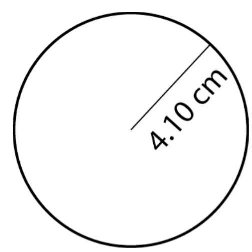
[Q6-2] A parking lot is 144m long and 47.66 m wide. What are the area and the perimeter of the lot?

7. **Rounding Errors** (Round-off Errors) – How to avoid them?
[Q7-1] A cow walks 3 km in 4 hours.

(a) What is the average speed of the cow?

(b) How far does it walk for 12 hours?

[Q7-2] Find the circumference of a circle with a radius of 4.10 cm



[Rule-7] **Keep at least one extra digit** throughout your calculations to avoid "rounding error"

6. Converting Units (W p20-21)

[Q16] If you walk at 3.00 mi/h, how fast is that in m/s?
(Conversion factor: 1 mi = 1.609 km)

II. Speed and Velocity

1. Average Speed and Instantaneous Speed

$$\text{Average Speed} = \frac{\text{distance}}{\text{elapsed time}} \quad [\text{m/s}]\ [\text{km/h}] \quad (1)$$

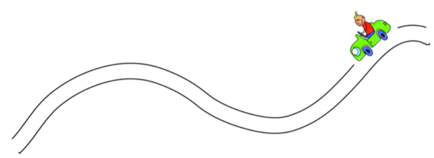
[Q1a] Shinkansen super express Nozomi#9 departs at 7:10 am at Tokyo and arrives at 12:29 at Hakata. The distance between Tokyo and Hakata is 1069.1 km. What is the average speed in km/h?


Fig 1a

[Q1b] In the above question, what is the significant figure for the solution?

Fig 1b

[Q2] In Q1, what is the average speed in m/s?



[Q3] You are driving at a constant **instantaneous speed** of 60 km/h. How far do you drive for 15 minutes?

Fig 4

[Q4] A car on a highway travels from A position to B position travels in 2.0 h at an average speed of 80 km/h. After that the car travels from B position to C position in 1.5 h at an average speed of 60 km/h.
(a) What is the distance from A position to C position.
(b) What is the average speed between A position to C position.

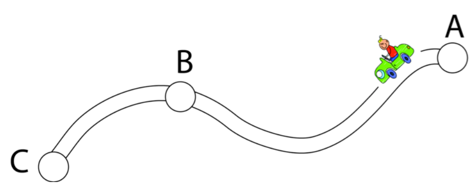


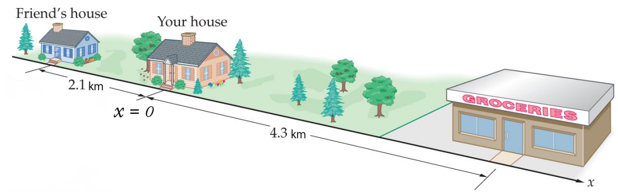
Fig 5

2 . Displacement and Velocity (W p42-53)

$$Displacement \equiv Change\ in\ position = \Delta x \equiv x' - x \quad (2)$$

$$Average\ Velocity = v_{av} \equiv \frac{\Delta x}{\Delta t} = \frac{x' - x}{t' - t} \quad (3)$$

[Q5] You leave your house, drive to the grocery store and then to your friend's house. What is the **distance** you've covered in your trip?



[Q6] In the above trip, what is the **displacement, Δx** when the origin O and the x coordinate are defined as shown the figure?

53)

[Q6'] In the above question, what is the **displacement, Δx** when the origin O is defined at the grocery store?

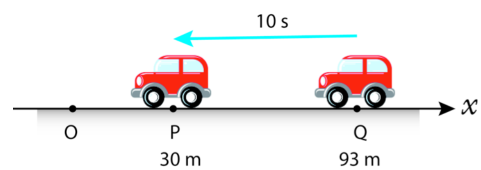


Fig 7

[Q7] In the figure shown, a car moves from Q to P in 10 seconds, where Q and P are 93m and 30m far from the origin, respectively. What is the average **speed** of the car?

Fig 9

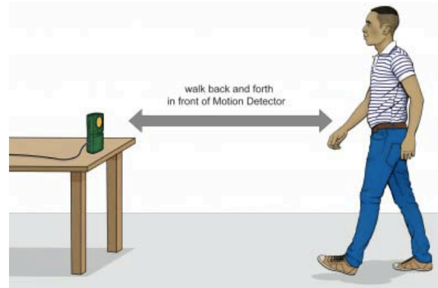
[Q8] The origin O and the x coordinate are defined as shown in the figure. If a car travels from Q to P in 10 seconds, what is the **average velocity, $\Delta x/\Delta t$,** of the car.

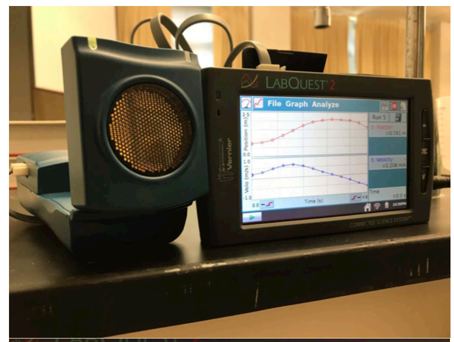
[Q9] If a boy runs 212 m west in 55.2 s, and then 288 east in 76.8 s, what is his average speed? What is his average velocity?

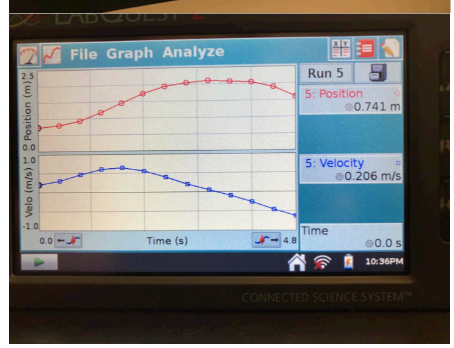
*[Q10] An object that is placed at x_1 = -10 m on the x axis moves to point x_2 = 11 m after 3.0 seconds. Find the average velocity during the movement.

3． Average Velocity and x–versus-t Graph　(W 54-57)

[Mini-Lab #1] Motion Detector







Experimental condition

Rate: 2.5 samples/s

Interval: 0.4 s/sample

Duration: 5 s

[Q11] The figure shown below visualizes a particle's motion by sketching its position as a function of time. In this case the particle moves in the positive x direction for 2 s, then reverses direction. Replot the same information with an x–versus-t graph where the vertical and horizontal axes represent the position, x, and time, t.

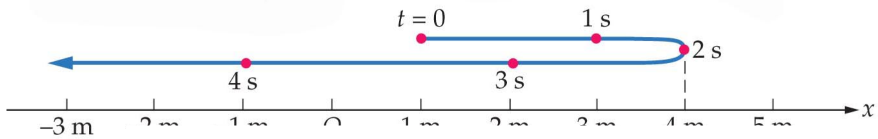


Fig. 11

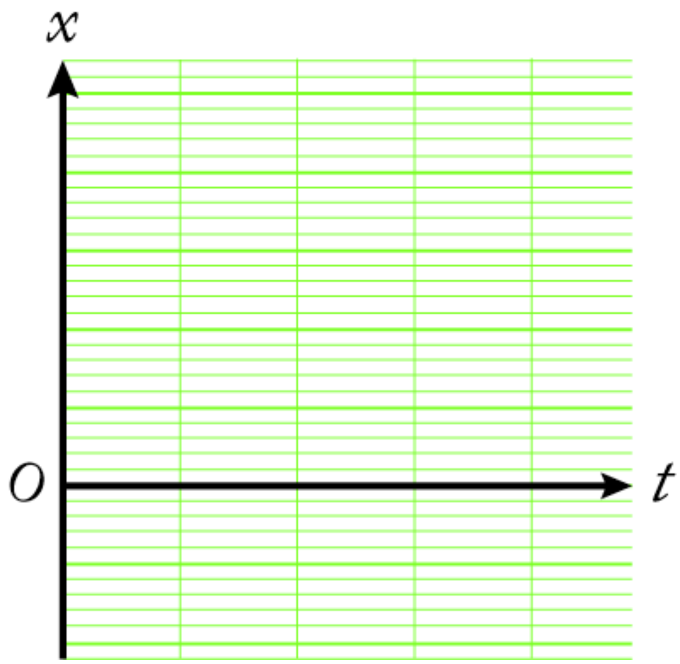


Fig. 12

[Q12] In the above question, find the average velocities, $\Delta x / \Delta t$, for the following intervals:

(a) Between t=0 s and t=4 s.
(b) Between t=0 s and t=3 s.
(c) Between t=2 s and t=3 s.

[Q13] In the above x–versus-t graph, draw a straight line connecting t=0 s and the position t=4 s. What is the meaning of the slope? Do the same thing for the above (b) and (c).

4. Instantaneous Velocity

[Q14] Fig. 14 shows the motion of a particle as the relation between the particle's position and time, with the corresponding numerical values of x and t given in Table 14. Find the average velocities, $v_{av}=\Delta x/\Delta t$, between the initial time, t_i, and the final time, t_f, in Table 14' and .

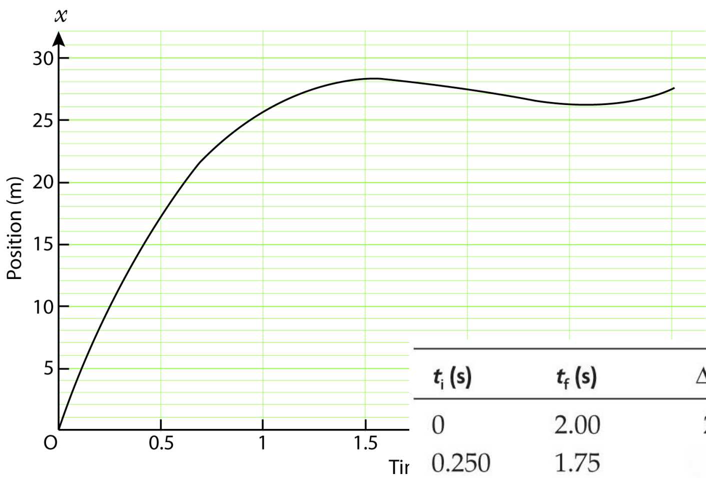


Fig. 14

Table 14

t (s)	x (m)
0	0
0.25	9.85
0.50	17.2
0.75	22.3
1.00	25.6
1.25	27.4
1.50	28.1

Table 14'

t_i (s)	t_f (s)	Δt (s)	x_i (m)	x_f (m)	Δx (m)	$v_{av} = \Delta x/\Delta t$(m/
0	2.00	2.00	0	27.4	27.4	13.7
0.250	1.75					
0.500	1.50					
0.750	1.25	0.50				
0.900	1.10					
0.950	1.05					

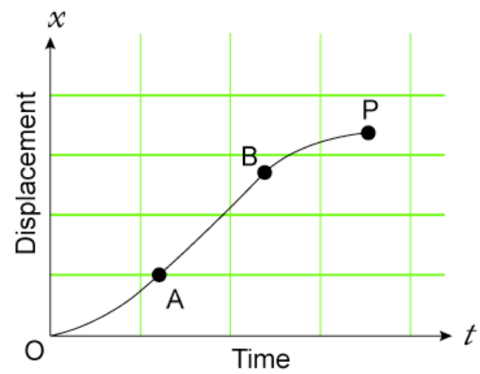
[Q15] The instantaneous velocity is defined as $v = \lim_{\Delta t\to 0}\frac{\Delta x}{\Delta t}$. Based on this definition, find the instantaneous velocity at t = 1 s in Fig. 14 from the calculation results of Table 14'. (The slope of the tangent line at a time on an x–versus-t graph corresponds to the instantaneous velocity at the time.)

$$Instantaneous\ Velocity = v \equiv \lim_{\Delta t\to 0}\frac{\Delta x}{\Delta t} \qquad (4)$$

[Q16] Fig. 16 shows an x–versus-t graph of the motion of an object that moves from O to P.

(a) In which interval does the object decrease its velocity gradually?

(b) In which interval does the object move at a constant velocity?



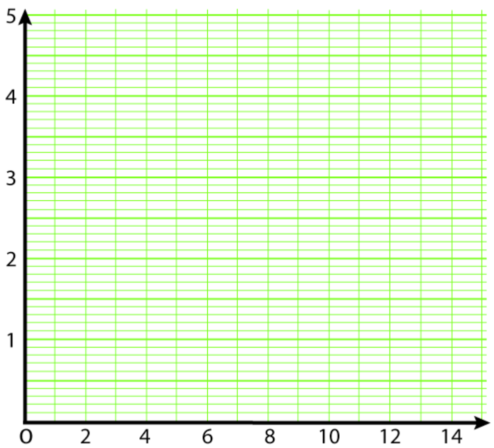
IV. Constant Velocity 1-D Motion　　(W 58~62)

Constant Velocity Motion　$x = vt$　　(7)

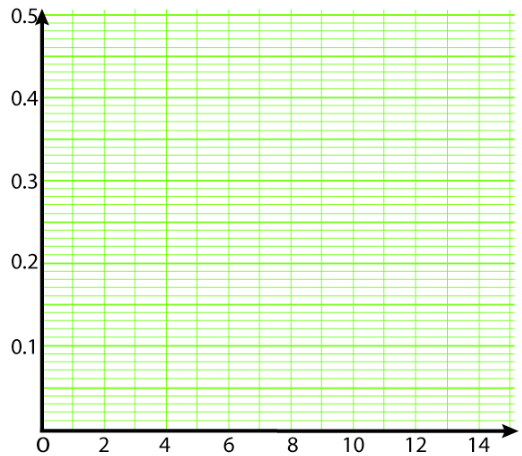
[Mini -Lab #2] Constant Speed Vehicle

[Q31] Fig. 31 shows a model car called "Constant Speed Vehicle."　Its speed is 0.31 m/s.　Draw two graphs expressing its motion for 15 seconds, x–versus-t graph and v–versus-t graph.

x–versus-t graph



v–versus-t graph



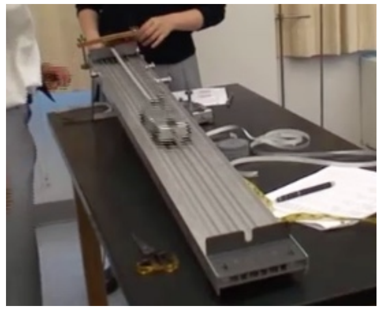
[Q32] Table shows a list of examples of speed shown by various matters.

	Speed
Growing of Hair	Approximately 15 cm/y
Moving of a Snail	Approximately 1.4 mm/s
Waking of a Man	Approximately 1.0 m/s
Flying of a Bee	5 m/s
Falling of a Sky Diver	55 m/s (200 km/h)
JR Super Express (Maximum)	93 m/s (336 km/h)
Propagation of Sound	340 m/s
Average Moving of a Oxygen Molecule (0℃)	460 m/s
Rotation of the Earth　(Equator)	465 m/s
Revolution of the Earth	30 km/s
Speed of Light (in Vacuum)	3.0×10^8 m/s

V. Acceleration　(W p72~81)

[Mini-Lab #3, Lab] Inclined Track and Spark Timer

Inclined track



Spark timer

$$Average\ Acceleration = a_{av} \equiv \frac{\Delta v}{\Delta t} = \frac{v' - v}{t' - t} \qquad (8)$$

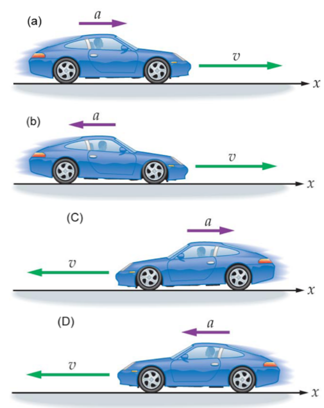
$$Instantaneous\ Acceleration = a \equiv \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} \qquad (9)$$

[Q33] Saab advertises a car that goes from 0 to 100 km/h in 6.5 s. What is the average acceleration of this car?

[Q34] An airplane has an average acceleration of 5.6 m/s^2 during takeoff.　How long does it take for the airplane to reach a speed of 240 km/h?

[Q35] A body moving at 10 m/s to the right begins to accelerate at a constant acceleration rate and then shows a speed of 16 m/s to the same direction in 2.0 s.　What is the acceleration rate during this period?

[Q36] Initially a body is moving at 10 m/s to the east. After 10 s, it shows a speed of 5.0 m/s in 10 period?



a
b
c
d

[Q37] Figs. a to d show four cars with the directions of velocity, v, and acceleration, a.　Which car's speed increases or decreases?

VI.　Motion with Constant Acceleration

(W p82~96)

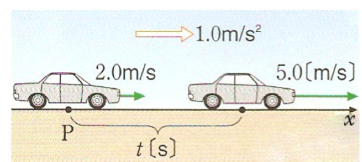


Fig. 42

Motion with Constant Acceleration

$$v = v_0 + a t \qquad (10)$$

$$x = v_0 t + \frac{1}{2} a t^2 \qquad (11)$$

$$v^2 - v_0^2 = 2 a x \qquad (12)$$

[Q42] A car is running at a constant acceleration of 1.0 m/s² in one dimension. The car passes a point P at a speed of 2.0 m/s.

(a)　How long does it take when the speed of the car reaches 5.0 m/s?
(b)　How many meters does the car run in 4.0 s after it passes the point P?
(c)　How many meters does the car run when its speed reaches 12 m/s?

[Q43] A boy rides a bike at 10 m/s and then put on the brake. The bike is stopping with a constant acceleration 1-D motion. The acceleration rate is 2.0 m/s^2 backward.

(a) How long does it take for the bike to stop after braking?

(b) How many meters does it move after braking?

(c) When the sharpness of the brake is changed, the bike moves 50 m to stop. What is the acceleration rate?

[Q44] When a jumbo jet takes off, it runs at an acceleration rate of 2.0 m/s^2 and floats up off the runway at a speed of 80 m/s in case of a windless condition.

(a) How long does it take to float up off the runway after starting?

(b) How many meters does the jet run on the runway?

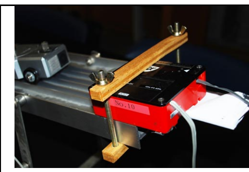
PhysicsLab-001	Analyzing the Accelerating Motion with a Spark Timer

1	Objectives	1) Record the movement of a Dynamics Cart descending on a slope to obtain the acceleration. 2) Investigate the relations between acceleration and mass
2	Hypothesis	The movement of a cart is constant-acceleration motion.
3	Safety	Do not drop a cart on your foot.

Preparation 準備

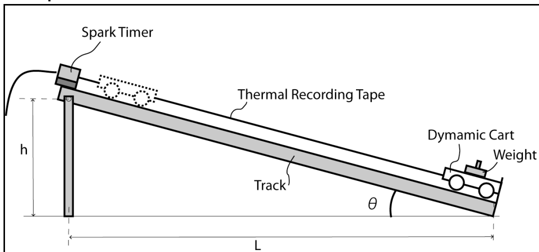
Spark Timer
Dynamic Cart, Weights (250 g each), Track, Scale
Wood board, Cramp, Extension code





Type-A

Type-B

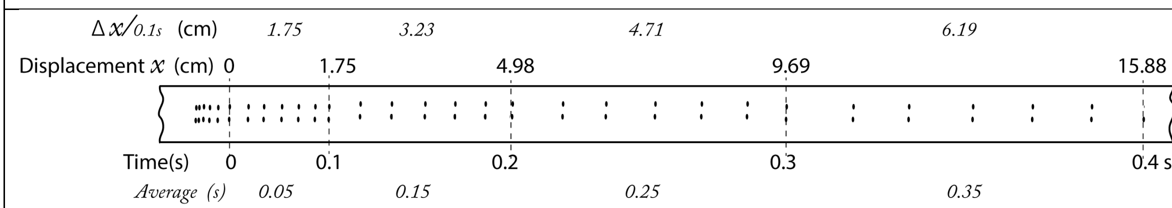
Experiments 実験



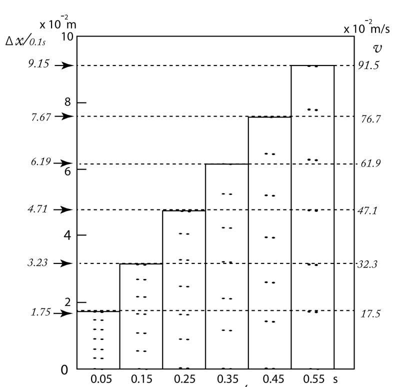
Measuremens
1. The mass of a Dynamic Cart
2. The height$(h)$and length(L) of the track to obtain the angle of the track θ $\tan\theta = h/L$

Spark Timer
・Frequency: 60 Hz
・On-Off: Switch Off→On just before the measurement

Measurements should be performed in 2 angles and 2 kinds of mass. <u>Total 4 measurements</u>.



Dots are printed every 1/60 s. Decide a start point. Make marks every 6 dots: the time of 6 dots corresponds to 0.100 s (1/60 s x 6 = 0.100 s), and the length corresponds to the displacement Δx per 0.100 s, namely the velocity Δx / Δt (m/0.100 s)
Cut at the marked places and put the pieces on graph paper.



Example

Time	t	s	0	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.0	1.1	1.2
Displacement	x	$\times10^{-2}$ m	0	2.35	6.25	11.65	18.60	27.15	37.24	48.85	61.95	76.65			
Displacement/0.1 s	Δx	$\times10^{-2}$ m		2.35	3.90	5.40	6.95	8.55	10.09	11.61	13.10	14.70			
Average Velocity	v	$\times10^{-2}$ m/s		23.5	39.0	54.0	69.5	85.5	100.9	116.1	131.0	147.0			
Average Acceleration	a	m/s²		1.55	1.50	1.55	1.60	1.54	1.52	1.50	1.60				
Central Time	t	s		0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95	1.05	1.15

Experiment – 1　(Angle: 　　　　° 　　　　Mass: 　　　　kg)

Time	t	s	0	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.0	1.1	1.2	1.3
Displacement	x	$\times10^{-2}$ m	0													
Displacement/0.1 s	Δx	$\times10^{-2}$ m														
Average Velocity	v	$\times10^{-2}$ m/s														
Average Acceleration	a	m/s²														
Central Time	t	s		0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95	1.05	1.15	1.25

Experiment – 2　(Angle: 　　　　° 　　　　Mass: 　　　　kg)

Time	t	s	0	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.0	1.1	1.2	1.3
Displacement	x	$\times10^{-2}$ m	0													
Displacement/0.1 s	Δx	$\times10^{-2}$ m														
Average Velocity	v	$\times10^{-2}$ m/s														
Average Acceleration	a	m/s²														
Central Time	t	s		0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95	1.05	1.15	1.25

Experiment – 3　(Angle: 　　　　° 　　　　Mass: 　　　　kg)

Time	t	s	0	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.0	1.1	1.2	1.3
Displacement	x	$\times10^{-2}$ m	0													
Displacement/0.1 s	Δx	$\times10^{-2}$ m														
Average Velocity	v	$\times10^{-2}$ m/s														
Average Acceleration	a	m/s²														
Central Time	t	s		0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95	1.05	1.15	1.25

Experiment – 4　(Angle: 　　　　° 　　　　Mass: 　　　　kg)

Time	t	s	0	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.0	1.1	1.2	1.3
Displacement	x	$\times10^{-2}$ m	0													
Displacement/0.1 s	Δx	$\times10^{-2}$ m														
Average Velocity	v	$\times10^{-2}$ m/s														
Average Acceleration	a	m/s²														
Central Time	t	s		0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95	1.05	1.15	1.25

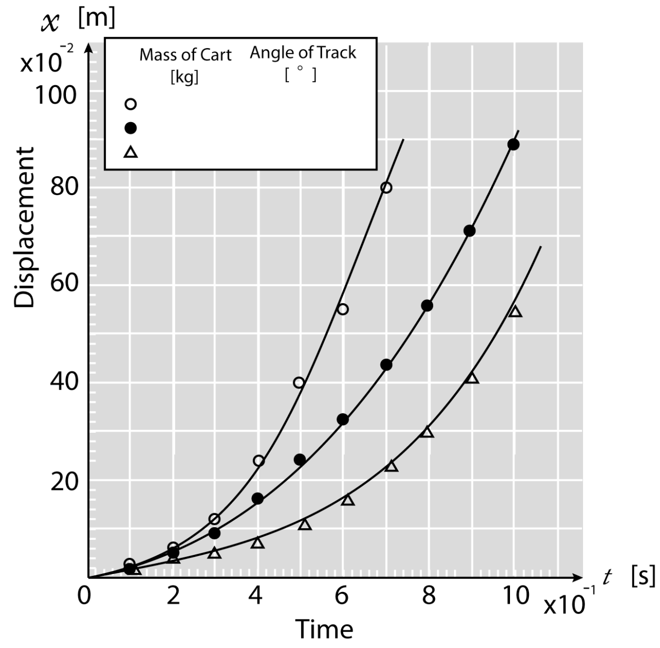


Figure 1　x-t graph

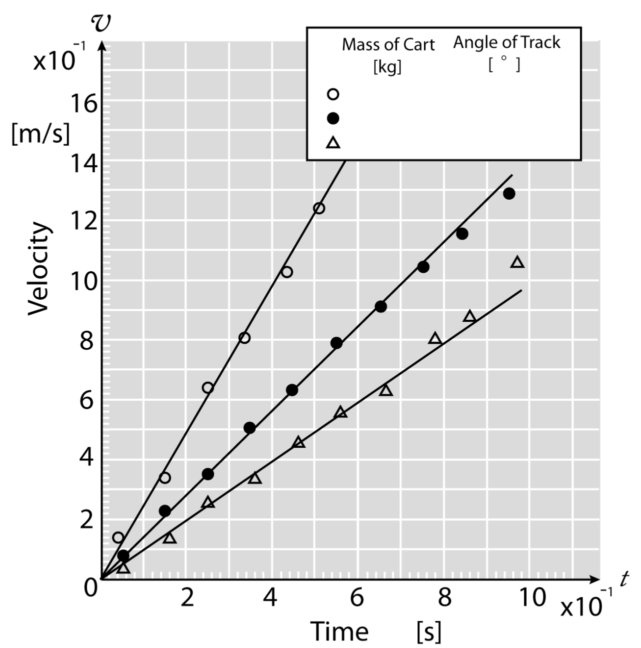


Figure 2　v-t graph

Lab Report

1. Report Cover　--- Use "Laboratory Report Cover for #1 Lab",　Write in script.
2. Data copy of the thermosensitive tape on graph sheets.
3. Tables
4. Figure --- x- t graph
5. Figure --- v – t graph　Obtain acceleration $a = \Delta v / \Delta t$ from the slope of v-t graph.
6. Table --- Summary of Results (Conditions --- Acceleration observed)
7. Discussion and Opinions

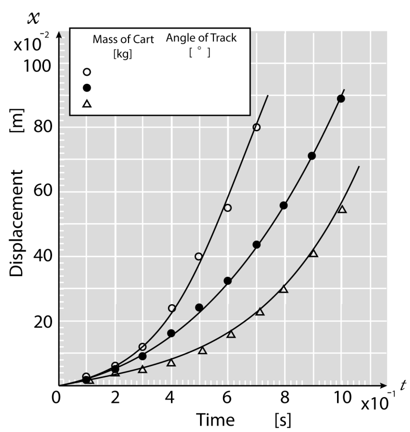


Fig. 2 $x - t$ Graph

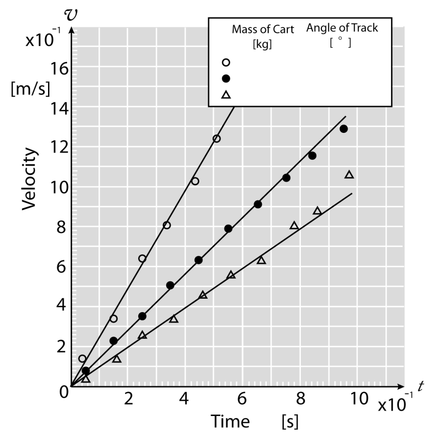
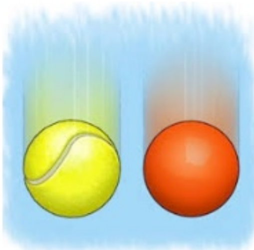
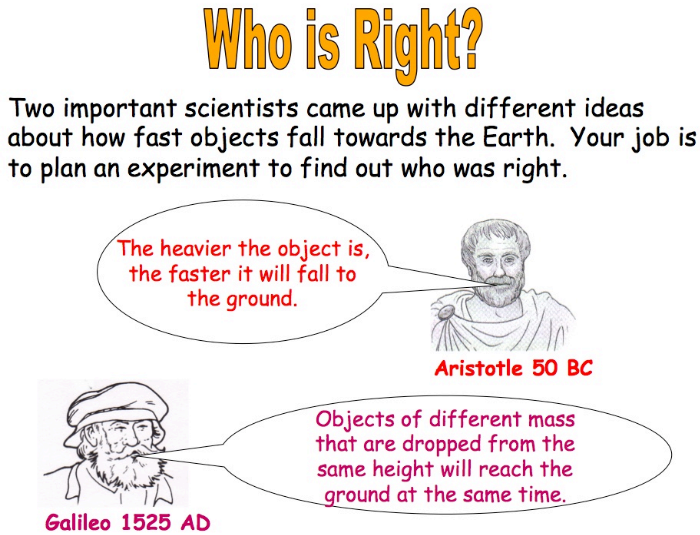


Fig. 1 $v - t$ Graph

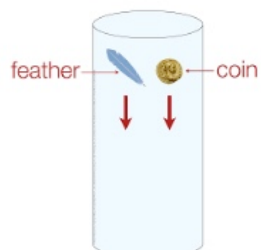
VII. Falling Motion (W p97~)



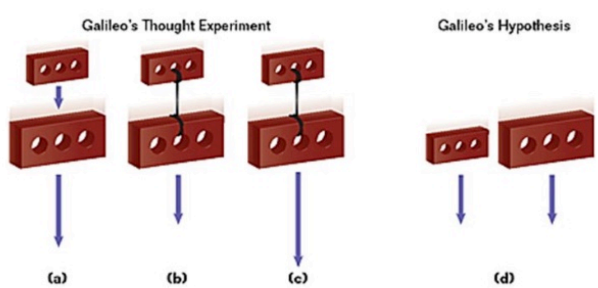


[Mini-Lab #4~7] Free Falling

"Galileo's Leaning Tower of Pisa Experiment"

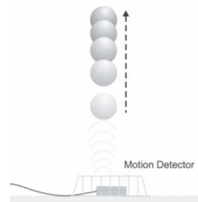
			
#4) Two Balls	#5) Coffee filter	#6) Coin and feather	#7) Hammer and feather (Apollo 15, 1971) https://www.youtube.com/watch?v=5C5_dOEyAfk

Galileo's Thought Experiment



- **Galileo's Hypothesis**: All objects fall at the same rate in the absence of air resistance

[Mini-Lab #8~10] Motion Detector

		
#8) Falling a book	#9) Falling coffee filter	#10) Ball Toss

1 . Free Falling (No Air Resistance)

Motion with Constant Acceleration

$v = v_0 + a\,t$ (10)

$x = v_0\,t + \frac{1}{2}\,a\,t^2$ (11)

$v^2 - v_0^2 = 2\,a\,x$ (12)

Free Falling (+ : downward)

$v = g\,t$ (13)

$y = \frac{1}{2}\,g\,t^2$ (14)

$v^2 = 2g\,y$ (15)

Vertical Throw-Up (+: upward)

$v = v_0 - g\,t$ (16)

$y = v_0\,t - \frac{1}{2}\,g\,t^2$ (17)

$v^2 - v_0^2 = -2\,g\,y$ (18)

Vertical Throw-Down (+: downward)

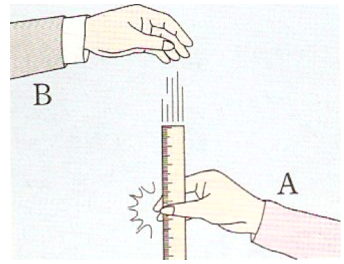
$v = v_0 + g\,t$ (19)

$y = v_0\,t + \frac{1}{2}\,g\,t^2$ (20)

$v^2 - v_0^2 = 2\,gy$ (21)

Use 9.80 m/s^2 as the gravitational acceleration rate in the following problems.

[Mini-Lab #11]

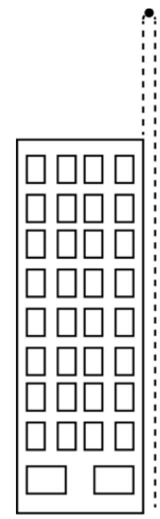


[Q57] A student B at the left holds a ruler and another student A at the right keeps his/her fingers open.　B suddenly falls the ruler freely and then A catches it.　The location of the ruler A catches is 20 cm lower than the original position.　What is A's reaction time?

[Q58]You dropped a stone freely from the bridge.

(1) Find the direction and magnitude of the stone's velocity 1.0 second later.
(2) How far does it fall during 1.0 second?
(3) You saw a splash 1.8 seconds after you had dropped the stone. Find the distance between the bridge and the water surface.

2． Vertical Throwing-Up



[Q59] You threw up a small ball vertically from the top of a building with a height of 88.2 m at an initial speed of 14.7 m/s.

(a) How long does it take until the ball reached the highest point?

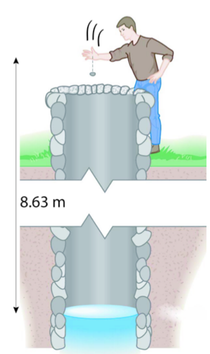
(b) Find the distance between the highest point and the top of the building.

(c) How long does the ball take to hit the ground?

(d) Find the speed just before hitting the ground.

[Q60] The world's highest fountain of water is located in Fountain Hills, Arizona.　The fountain rises to a height of 560 ft or 171 m. (a) What is the initial speed of the water?　(b) How long does it take for water to reach the top of the fountain?

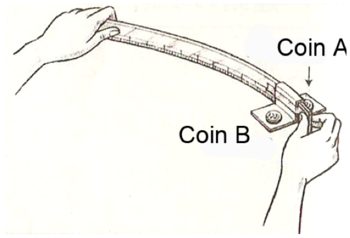
3． Vertical Throwing-Down



[Q61] A boy throws a stone down into a well that is 8.63 m deep and sees the splash after 1.20 s.　What is the initial speed?

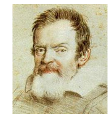
VIII. Projectile Motion – Zero Launch Angle (W p131~136)

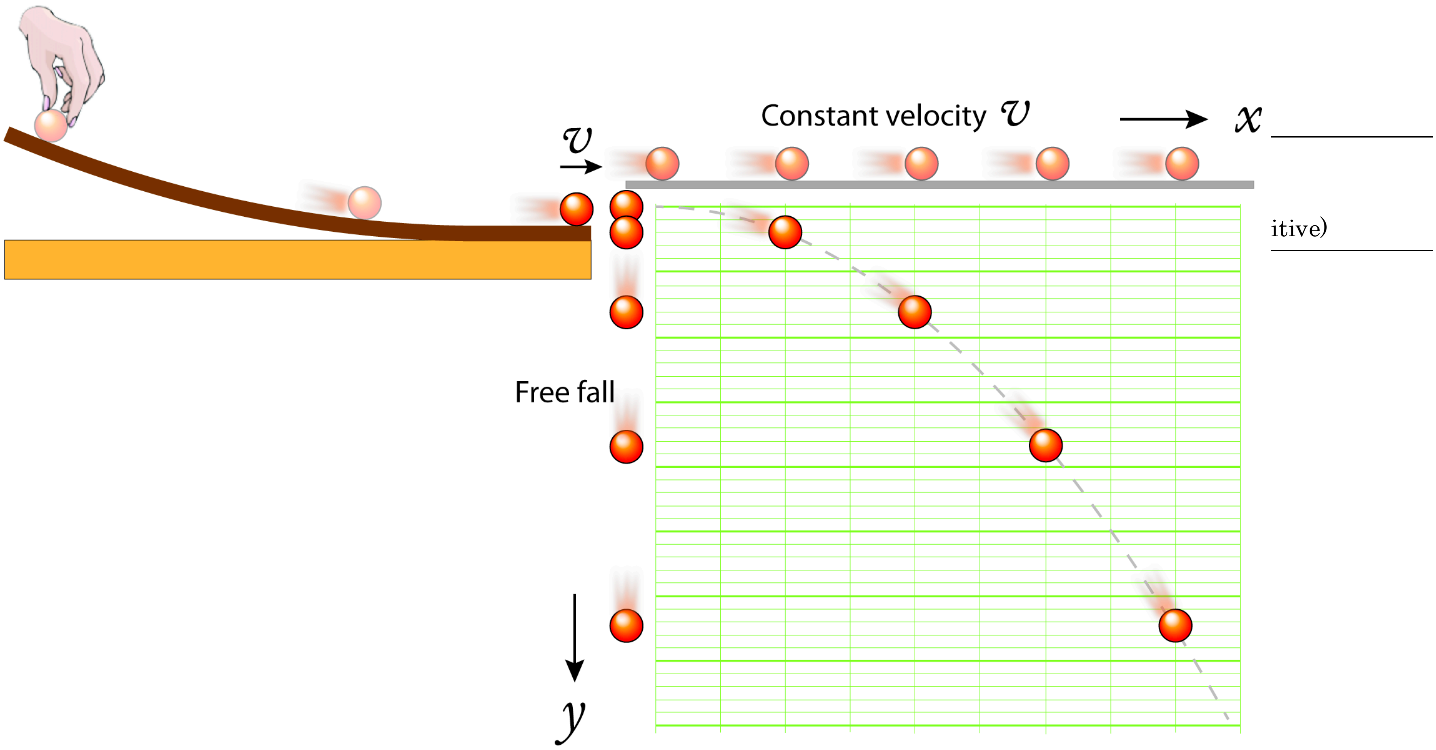
[Mini-Lab #12] Using the apparatus as shown two coins are let start at the same time: one falls freely and vertically and the other is shot horizontally. Which coin hit the ground faster?

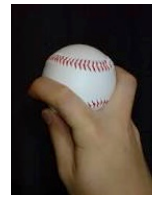


[Mini-Lab #13] Trajectory Apparatus

[Galileo's Hypothesis] A projectile motion can be broken down into two components: A Horizontal Motion and a Vertical Motion.



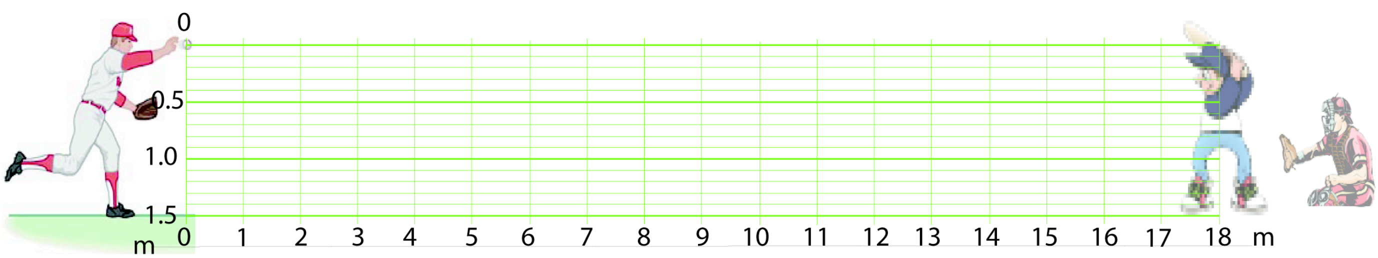




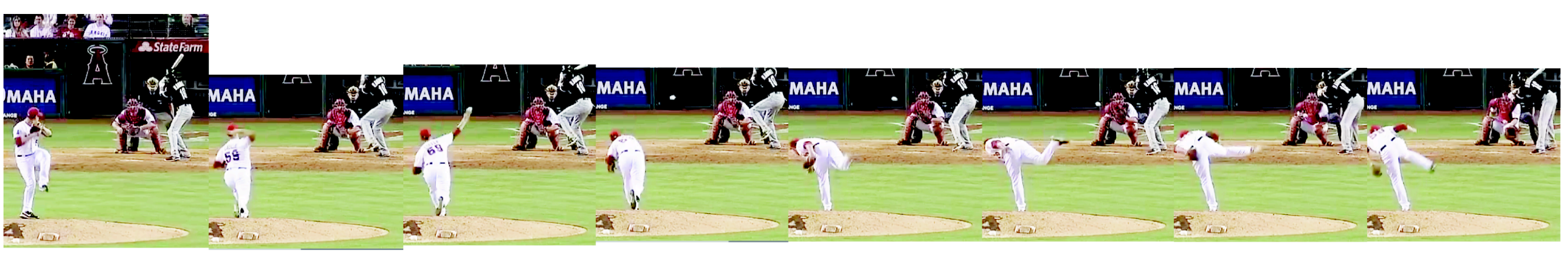
[Mini-Lab #14]　Fork Ball

[Q73] A pitcher throws a ball horizontally at a speed of 135 km/h.　Assuming that the effect of air is negligible, draw the trajectory how the ball travels.

Horizontal distance	x [m]	0	3	6	9	12	15	18
Time	t [s]							
Vertical distance	y [m]							



[Q74] Compare your result with Robert Coello's forkball pitch.



[Q74]　A bullet is fired horizontally from a height of h [m] at a speed of v_0 [m/s].

(a) Find the acceleration rates, velocities and displacements of the bullet in terms components as functions of time.

(b) How far does the bullet travel horizontally from the bottom of the building and the place the bullet hit the ground assuming h =33.8 m, v_0 = 400 m/s (4.00 x 10^2 m/s) and the ground is flat?

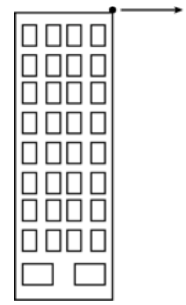


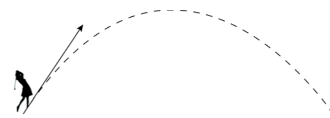
Fig.74

IX. Projectile Motion – General Launch Angle

Projectile Motion - General Launch Angle		
$v_x = v_{ox} = v_o \cos\theta,$	$x = v_{0x}t$	(5)
$v_y = v_{oy} - gt,$	$y = v_{0y}t - \frac{1}{2}gt^2$	(6) Upward: positive

[Mini-Lab #15] Projectile Launcher

[Q74] A golfer tees off on level ground, giving the ball an initial speed of v_0 [m/s] and an initial direction of θ [°]above the horizontal.



(a) Find the acceleration rates, velocities and displacements of the ball in terms of components as functions of time.

Answer the following questions supposing $v_0 = 52.7$ m/s and $\theta = 42.5°$.

(b) What are the horizontal and vertical components of the initial speed?
(c) How long does the ball take to reach the highest point?
(d) What is the maximum height of the projectile from the ground? The ground is assumed to be flat.
(e) How long does it travel before it hit the ground?
(f) How far does it travel before it hit the ground?
(g) What is the speed of the ball just before it hits the ground?

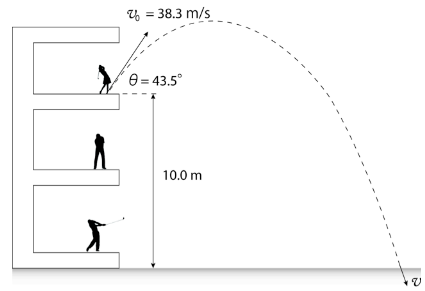
[Q75] A golfer tees off at an initial speed of 38.3 m/s and at an angle of 43.5°　above the horizontal from a height of 10.0 m.

(a) What are the horizontal and vertical components of the initial speed?

(b) How long does the ball take to reach the highest point?

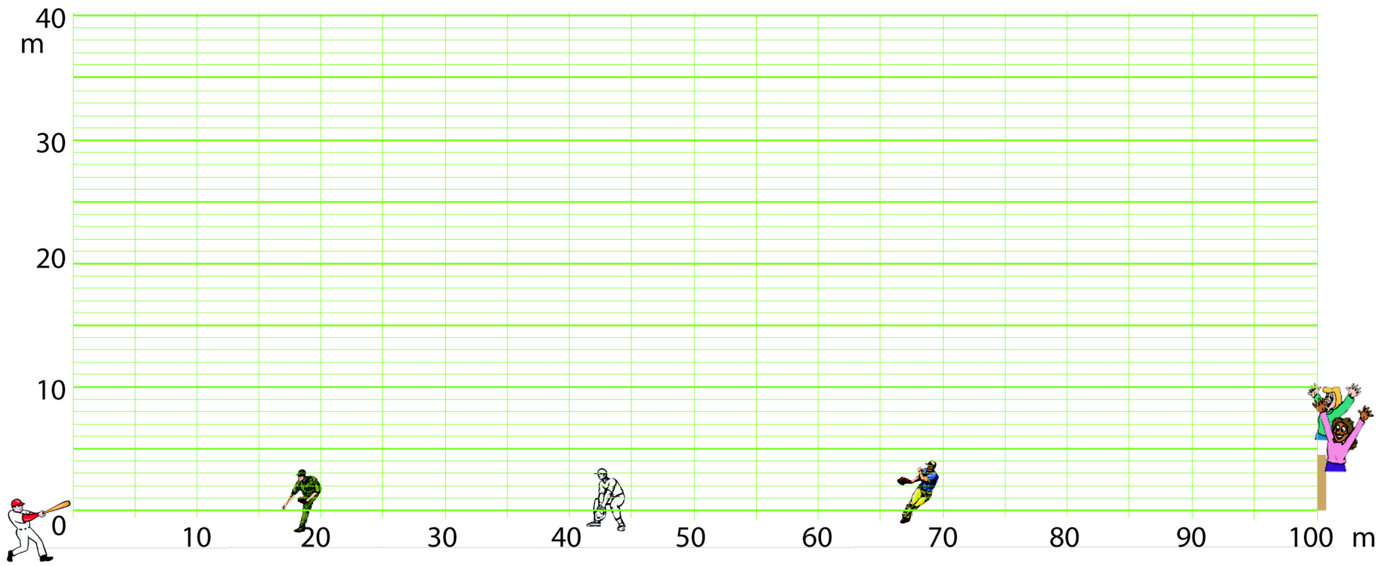
(c) What is the maximum height of the projectile from the ground? The ground is assumed to be flat.

(h)　What is the speed of the ball just before it hits the ground?

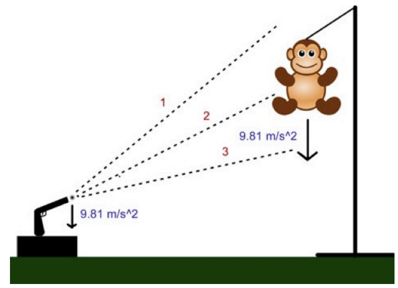


[Q22] A batter hit a ball giving the ball an initial speed of 135 km/h and an initial direction of 45° above the horizontal. Assuming that the effect of air is negligible, draw the trajectory how the ball travels.

Horizontal distance	x [m]	0	20	40	60	80	100	120
Time	t [s]							
Vertical distance	y [m]							



[Mini-Lab #16] The Monkey and the Hunter



A hunter fires a dart gun with a harmless sedative at a monkey hanging from a vine a distance h vertically above the dart gun and a distance R horizontally away from the dart gun. The hunter aims directly at the monkey and fires, but just as the hunter fires, the monkey, using its incredible spider-monkey sense, realizes what's up and drops from the vine. Does the monkey avoid the dart?

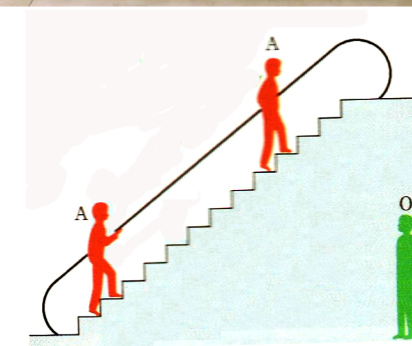
III. Combining Velocity, Relative Velocity, Relativity of Velocity

1. Combining Velocity　(W p127)

Combining velocity (1D): $v = v_1 + v_2$	(5)

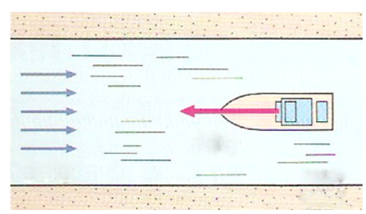
[Mini-Lab #17] Running Cart on a Moving Walkway

[Q22] There is a moving walkway that has a speed of 2.2 m/s relative to the ground. You walk at a speed of 1.3 m/s when walking on the ground. What is your velocity relative to the ground assume that you walk with the same speed on the walkway as you do on the ground?



[Q23-a] An up escalator is moving at a speed of 0.50 m/s. A person is walking upwards on the steps of the escalator at 1.2 m/s. What is the velocity of the person when another person standing on the ground observes?

[Q23-b] A down escalator is moving at a speed of 0.50 m/s. A person is walking upwards on the steps of the escalator at 1.2 m/s. What is the velocity of the person when another person standing on the ground observes?



[Q24] There is a boat whose speed relative to the water is 5.0 m/s. When the boat runs upstream on a river flowing at 2.0 m/s, what is the velocity of the boat relative to the ground?

[Q25] In the previous question, what is the velocity of the boat relative to the ground if the boat runs downstream?

2. Relative Velocity

$\vec{v}_{AB}$: The velocity of A relative to B (The velocity of A observed by B)

Relative Velocity (1D) $\vec{v}_{AB} = v_A - v_B$

[Q18]
Two cars, A and B, are running both to the right direction. A car, A, runs at a speed of 10 m/s whereas B does 15 m/s. (a) What is the relative velocity of the car B observed by the passenger of the car A? (b) What is the relative velocity of the car A observed by the passenger of the car B?

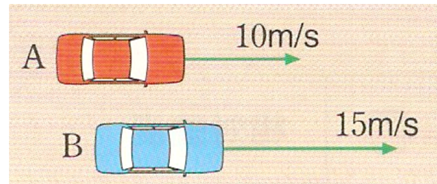


Fig 18

[Q19] In the previous question, the car B runs to the left at 15 m/s. What is the relative velocity of the car B observed by the passenger of the car A?


Fig 20

[Q20] A bus is running at a speed of 50 km/h. A passenger of the bus observes a car passing the bus relatively at a speed of 10 km/h. Find the actual velocity of the car.

[Q44] When a jumbo jet takes off, it runs at an acceleration rate of 2.0 m/s^2 and floats up off the runway at a speed of 80 m/s in case of a windless condition.
(c) How long does it take to float up off the runway after starting?
(d) How many meters does the jet run on the runway?
In case of a windy condition, a jet floats up when its relative velocity to the air reaches 80 m/s. Answer the following questions supposing that a jet is running toward windward in wind blowing at 10 m/s.
(e) What is the speed of the jet relative to the ground when the jet floats up?
(f) How many meters does the jet run on the runway?

IV. Vectors and Components (W p113~126)

1. Vector - Diagram

2. A vector and its components $A_x = A\cos\theta,\quad A_y = A\sin\theta$

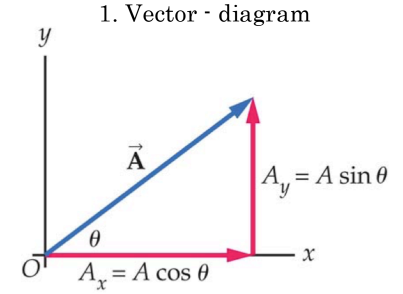
3. Adding and Subtracting Vectors

$$\vec{C} = \vec{A} + \vec{B} \quad\rightarrow\quad C_x = A_x + B_x,\quad C_y = A_y + B_y$$

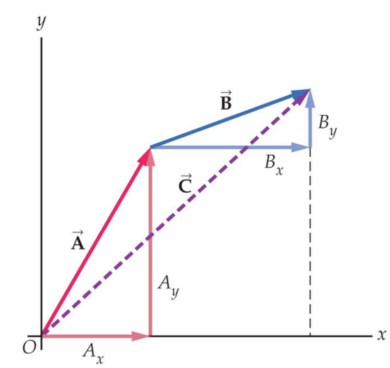
4. Components → Magnitude and Direction

$$C_x,\ C_y \quad\rightarrow\quad C = \sqrt{{C_x}^2 + {C_y}^2},\quad \theta = \tan^{-1}\frac{C_y}{C_x}$$

1. Vector - diagram



2. Components

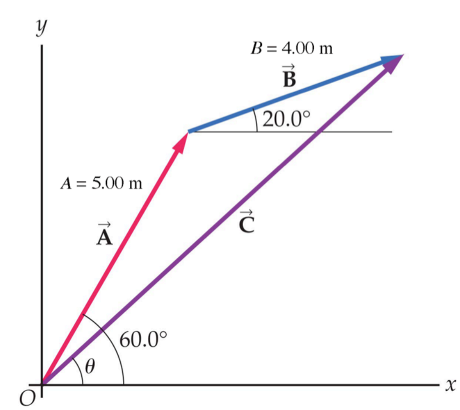


3. Addition

[Q1] Find A_x and A_y for the vector $\vec{A}$ with magnitude and direction given by $A = 3.5$ m and $\theta = 66°$, respectively.

[Q2] Find B and θ for the vector $\vec{B}$ with components Bx = 75.5 m and By = 6.20 m.

[Q3] In Fig. Q3, find C and θ for the vector $\vec{C}$ where $\vec{C} = \vec{A} + \vec{B}$.



[Q3]

Combining velocity (2D)　(W p128~130)

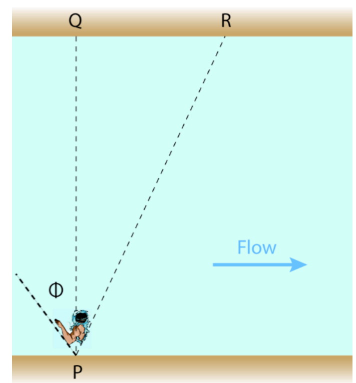
"The velocity of A relative to B: $\vec{v}_{AB}$

Combing Velocity　$v = v_1 + v_2 \rightarrow \quad \vec{v}_{BG} = \vec{v}_{BW} + \vec{v}_{WG}$

$\vec{v}_{BG}$: The velocity of a boat relative to the ground

$\vec{v}_{BW}$: The velocity of a boat relative to water

$\vec{v}:_{WG}$: The velocity of water relative to the ground



[Q26] You swim at 1.2 m/s relative to water.
Now you point at the right angle to the bank on a river flowing 0.90 m/s.　The width of the river is 72 m.

(a) What is your speed relative to the ground?
(b) How long does it take to cross the river to the other side?
(c) What is the distance between the point R you arrive at and the opposite point Q?

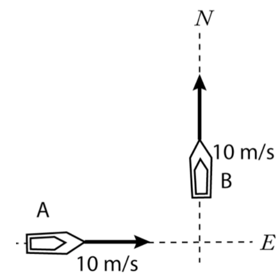
This time you want to cross the river to the opposite point Q.

(d) What angle Φ should you take?
(e) What is your speed relative to the ground?
(f)

Relative Velocity (2D)

$$v_{AB} = v_A - v_B \qquad \vec{v}_{AB} = \vec{v}_{AG} + \vec{v}_{GB} = \vec{v}_{AG} - \vec{v}_{BG}$$

[Q29] On a calm lake a motorboat A is moving due east at a speed of 10 m/s. Another motorboat B is passing in front of A at a speed of 10 m/s.　How does the passenger on the motorboat A experience the velocity of B?



3. Relativity of Velocity

[Mini-Lab #18] “Train”

汽車（きしゃ）　汽車　ポッポ　ポッポ
シュッポ　シュッポ　シュッポッポ
僕等（ぼくら）をのせて
シュッポ　シュッポ　シュッポッポ
スピード　スピード　窓（まど）の外
畑（はたけ）も　とぶ　とぶ　家もとぶ
走れ　走れ　走れ
鉄橋（てっきょう）だ　鉄橋だ　たのしいな

”The velocity of A relative to B”: $\vec{v}_{AB}$

Combining Velocity $\vec{v}_{GA} = \vec{v}_{GB} + \vec{v}_{BA}$ $\qquad \vec{v} = \vec{v}_1 + \vec{v}_2$ (5)

Relativity of Velocity $\vec{v}_{GA} = -\vec{v}_{AG}$ (6)

Relative Velocity $\vec{v}_{AB} = \vec{v}_{AG} + \vec{v}_{GB}$

$= \vec{v}_{AG} - \vec{v}_{BG} = v_A - v_B$ (7)

Trigonometric Function Table

角	正弦 (sin)	余弦 (cos)	正接 (tan)
0.0°	0.0000	1.0000	0.0000
0.5°	0.0087	1.0000	0.0087
1.0°	0.0175	0.9998	0.0175
1.5°	0.0262	0.9997	0.0262
2.0°	0.0349	0.9994	0.0349
2.5°	0.0436	0.9990	0.0437
3.0°	0.0523	0.9986	0.0524
3.5°	0.0610	0.9981	0.0612
4.0°	0.0698	0.9976	0.0699
4.5°	0.0785	0.9969	0.0787
5.0°	0.0872	0.9962	0.0875
5.5°	0.0958	0.9954	0.0963
6.0°	0.1045	0.9945	0.1051
6.5°	0.1132	0.9936	0.1139
7.0°	0.1219	0.9925	0.1228
7.5°	0.1305	0.9914	0.1317
8.0°	0.1392	0.9903	0.1405
8.5°	0.1478	0.9890	0.1495
9.0°	0.1564	0.9877	0.1584
9.5°	0.1650	0.9863	0.1673
10.0°	0.1736	0.9848	0.1763
10.5°	0.1822	0.9833	0.1853
11.0°	0.1908	0.9816	0.1944
11.5°	0.1994	0.9799	0.2035
12.0°	0.2079	0.9781	0.2126
12.5°	0.2164	0.9763	0.2217
13.0°	0.2250	0.9744	0.2309
13.5°	0.2334	0.9724	0.2401
14.0°	0.2419	0.9703	0.2493
14.5°	0.2504	0.9681	0.2586
15.0°	0.2588	0.9659	0.2679
15.5°	0.2672	0.9636	0.2773
16.0°	0.2756	0.9613	0.2867
16.5°	0.2840	0.9588	0.2962
17.0°	0.2924	0.9563	0.3057
17.5°	0.3007	0.9537	0.3153
18.0°	0.3090	0.9511	0.3249
18.5°	0.3173	0.9483	0.3346
19.0°	0.3256	0.9455	0.3443
19.5°	0.3338	0.9426	0.3541
20.0°	0.3420	0.9397	0.3640
20.5°	0.3502	0.9367	0.3739
21.0°	0.3584	0.9336	0.3839
21.5°	0.3665	0.9304	0.3939
22.0°	0.3746	0.9272	0.4040
22.5°	0.3827	0.9239	0.4142

角	正弦 (sin)	余弦 (cos)	正接 (tan)
22.5°	0.3827	0.9239	0.4142
23.0°	0.3907	0.9205	0.4245
23.5°	0.3987	0.9171	0.4348
24.0°	0.4067	0.9135	0.4452
24.5°	0.4147	0.9100	0.4557
25.0°	0.4226	0.9063	0.4663
25.5°	0.4305	0.9026	0.4770
26.0°	0.4384	0.8988	0.4877
26.5°	0.4462	0.8949	0.4986
27.0°	0.4540	0.8910	0.5095
27.5°	0.4617	0.8870	0.5206
28.0°	0.4695	0.8829	0.5317
28.5°	0.4772	0.8788	0.5430
29.0°	0.4848	0.8746	0.5543
29.5°	0.4924	0.8704	0.5658
30.0°	0.5000	0.8660	0.5774
30.5°	0.5075	0.8616	0.5890
31.0°	0.5150	0.8572	0.6009
31.5°	0.5225	0.8526	0.6128
32.0°	0.5299	0.8480	0.6249
32.5°	0.5373	0.8434	0.6371
33.0°	0.5446	0.8387	0.6494
33.5°	0.5519	0.8339	0.6619
34.0°	0.5592	0.8290	0.6745
34.5°	0.5664	0.8241	0.6873
35.0°	0.5736	0.8192	0.7002
35.5°	0.5807	0.8141	0.7133
36.0°	0.5878	0.8090	0.7265
36.5°	0.5948	0.8039	0.7400
37.0°	0.6018	0.7986	0.7536
37.5°	0.6088	0.7934	0.7673
38.0°	0.6157	0.7880	0.7813
38.5°	0.6225	0.7826	0.7954
39.0°	0.6293	0.7771	0.8098
39.5°	0.6361	0.7716	0.8243
40.0°	0.6428	0.7660	0.8391
40.5°	0.6494	0.7604	0.8541
41.0°	0.6561	0.7547	0.8693
41.5°	0.6626	0.7490	0.8847
42.0°	0.6691	0.7431	0.9004
42.5°	0.6756	0.7373	0.9163
43.0°	0.6820	0.7314	0.9325
43.5°	0.6884	0.7254	0.9490
44.0°	0.6947	0.7193	0.9657
44.5°	0.7009	0.7133	0.9827
45.0°	0.7071	0.7071	1.0000

角	正弦 (sin)	余弦 (cos)	正接 (tan)
45.0°	0.7071	0.7071	1.0000
45.5°	0.7133	0.7009	1.0176
46.0°	0.7193	0.6947	1.0355
46.5°	0.7254	0.6884	1.0538
47.0°	0.7314	0.6820	1.0724
47.5°	0.7373	0.6756	1.0913
48.0°	0.7431	0.6691	1.1106
48.5°	0.7490	0.6626	1.1303
49.0°	0.7547	0.6561	1.1504
49.5°	0.7604	0.6494	1.1708
50.0°	0.7660	0.6428	1.1918
50.5°	0.7716	0.6361	1.2131
51.0°	0.7771	0.6293	1.2349
51.5°	0.7826	0.6225	1.2572
52.0°	0.7880	0.6157	1.2799
52.5°	0.7934	0.6088	1.3032
53.0°	0.7986	0.6018	1.3270
53.5°	0.8039	0.5948	1.3514
54.0°	0.8090	0.5878	1.3764
54.5°	0.8141	0.5807	1.4019
55.0°	0.8192	0.5736	1.4281
55.5°	0.8241	0.5664	1.4550
56.0°	0.8290	0.5592	1.4826
56.5°	0.8339	0.5519	1.5108
57.0°	0.8387	0.5446	1.5399
57.5°	0.8434	0.5373	1.5697
58.0°	0.8480	0.5299	1.6003
58.5°	0.8526	0.5225	1.6319
59.0°	0.8572	0.5150	1.6643
59.5°	0.8616	0.5075	1.6977
60.0°	0.8660	0.5000	1.7321
60.5°	0.8704	0.4924	1.7675
61.0°	0.8746	0.4848	1.8040
61.5°	0.8788	0.4772	1.8418
62.0°	0.8829	0.4695	1.8807
62.5°	0.8870	0.4617	1.9210
63.0°	0.8910	0.4540	1.9626
63.5°	0.8949	0.4462	2.0057
64.0°	0.8988	0.4384	2.0503
64.5°	0.9026	0.4305	2.0965
65.0°	0.9063	0.4226	2.1445
65.5°	0.9100	0.4147	2.1943
66.0°	0.9135	0.4067	2.2460
66.5°	0.9171	0.3987	2.2998
67.0°	0.9205	0.3907	2.3559
67.5°	0.9239	0.3827	2.4142

角	正弦 (sin)	余弦 (cos)	正接 (tan)
67.5°	0.9239	0.3827	2.4142
68.0°	0.9272	0.3746	2.4751
68.5°	0.9304	0.3665	2.5386
69.0°	0.9336	0.3584	2.6051
69.5°	0.9367	0.3502	2.6746
70.0°	0.9397	0.3420	2.7475
70.5°	0.9426	0.3338	2.8239
71.0°	0.9455	0.3256	2.9042
71.5°	0.9483	0.3173	2.9887
72.0°	0.9511	0.3090	3.0777
72.5°	0.9537	0.3007	3.1716
73.0°	0.9563	0.2924	3.2709
73.5°	0.9588	0.2840	3.3759
74.0°	0.9613	0.2756	3.4874
74.5°	0.9636	0.2672	3.6059
75.0°	0.9659	0.2588	3.7321
75.5°	0.9681	0.2504	3.8667
76.0°	0.9703	0.2419	4.0108
76.5°	0.9724	0.2334	4.1653
77.0°	0.9744	0.2250	4.3315
77.5°	0.9763	0.2164	4.5107
78.0°	0.9781	0.2079	4.7046
78.5°	0.9799	0.1994	4.9152
79.0°	0.9816	0.1908	5.1446
79.5°	0.9833	0.1822	5.3955
80.0°	0.9848	0.1736	5.6713
80.5°	0.9863	0.1650	5.9758
81.0°	0.9877	0.1564	6.3138
81.5°	0.9890	0.1478	6.6912
82.0°	0.9903	0.1392	7.1154
82.5°	0.9914	0.1305	7.5958
83.0°	0.9925	0.1219	8.1443
83.5°	0.9936	0.1132	8.7769
84.0°	0.9945	0.1045	9.5144
84.5°	0.9954	0.0958	10.385
85.0°	0.9962	0.0872	11.430
85.5°	0.9969	0.0785	12.706
86.0°	0.9976	0.0698	14.301
86.5°	0.9981	0.0610	16.350
87.0°	0.9986	0.0523	19.081
87.5°	0.9990	0.0436	22.904
88.0°	0.9994	0.0349	28.636
88.5°	0.9997	0.0262	38.188
89.0°	0.9998	0.0175	57.290
89.5°	1.0000	0.0087	114.59
90.0°	1.0000	0.0000	– – –

Sauare and Root

n	n^2	$\sqrt{n}$
1	1	1.0000
2	4	1.4142
3	9	1.7321
4	16	2.0000
5	25	2.2361
6	36	2.4495
7	49	2.6458
8	64	2.8284
9	81	3.0000
10	100	3.1623