

EO109
General Physics(I) (Chinese):普通物理 (一)
Semester 103-1

白小明
Jonathon David White
元智大学光电系
R70740, R70723
WhiteJD@XiaoTu.com

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“To Him Who Is Above And Beyond All”

Name	
Student ID	
Class ID	
Cell Phone	
Email	

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0. Introduction

0.1 Facilitators

a. Lecturer: 白小明 小明白

1. Background: <http://www.xiaotu.com/whitejd/per/index.htm>

Jonathon David White was born in Oakville, Canada but has since lived in many other countries. Even during his undergraduate days at McMaster University, he already had a cosmopolitan outlook on life, being active in the Chinese Christian Fellowship. After obtaining his Ph.D., also from McMaster University, he worked and taught in China, Japan, and Taiwan – where he met and married Wu Xiuman – and then Malaysia at Multimedia University. After 4 years (1999-2003) in the Faculty of Engineering and Technology at the Melaka campus of Multimedia University, he moved with his family to Taiwan. He is now Associate Professor at Yuan Ze University. He and his wife have two daughters, Ai-en (Charity Grace) and Liang-En (Ruth Ann) as well as two sons, You-en (Johann Donald) and Li-En (Leon Joshua). Dr. White's experience in programming has largely been self-taught on a "need-to-know" basis. His introduction to ANSI-C came in 1994, when he took a position in the Ocean Remote Sensing Institute in Qingdao, China. Upon arrival, he was given a book introducing ANSI-C (in Chinese) and told to interface a computer, laser and detector – allowing him to simultaneously learn ANSI-C and Chinese! This "need-to-know" has resulted in the the method of teaching of this course.

2. Family: 爱有力量 <https://www.youtube.com/watch?v=G1h9AhUh7o8>
3. Research: <http://www.xiaotu.com>
4. Email: whitejd@xiaotu.com
5. Calendar: <http://www.xiaotu.com>
6. Office: R70740, R70723 & Lab
7. Office Hours: Wed 1600-1800, Thursday 1000-1200

b. Teaching Assistants

1. Kevin: Vietnamese Ph.D. student R70740
2. Aray: Taiwanese Ph.D. student R70740
3. Amanuel: Ethiopian Graduate Student R70740

0.2 Respect

a. Classroom Expectations

1. Arrive on Time (after attendance deemed absent)
2. Listen to Lectures
3. Ask Questions (bonus marks)
4. Listen to fellow students
5. Food and Drinks are OK in the classroom
6. Do not leave garbage in classroom
7. During class: (as this distracts other students)
 - i. No FACEBOOK,
 - ii. No computer games
 - iii. No checking email
 - iv. No videos

Students disobeying rules will be asked to leave the classroom. If cited more than three (3) times, student will be asked to drop the course.

b. Rules for the Computer Room 電腦教室使用規定

1. 上課注意事項：
 - i. 準時到教室，遲到禁止進入教室。
 - ii. 在教室裡請勿飲食，食物和飲料禁止帶進室內。

- iii. 每位同學上課都有固定位置，點名前請勿隨意更換位子。
 - iv. 請勿隨意更動教室內電腦設定。
2. 下課注意要點：
- i. 請將垃圾帶走，丟在安全門外的垃圾桶。
 - ii. 請將座椅歸回原本的位置。
 - iii. 每個禮拜會安排值日生在課後檢查教室，請務必配合。
 - iv. 有違反規定的將登記扣分
 - v. 以上如有不清楚的部份，請找老師或助教協助

0.3 Textbooks/References/Websites

a. Textbook

Physics for Scientists and Engineers: A Strategic Approach with Modern Physics (3rd Edition)
Hardcover – January 7, 2012 ISBN-13: 978-0321740908

The textbook will be used for the two courses in physics offered by our department. Key concepts are covered in the animations and view graphs

b. Websites

1. <http://www.xiaotu.com/tea/yzueo101.htm> (Grade information and some links)
2. <http://exciton.eo.yzu.edu.tw/~courses/eophys/> Animations
3. <http://www.animations.physics.unsw.edu.au/> Animations
4. <http://www.masteringphysics.com> Textbook Website / Homework

0.4 Course Overview

This course is the first in a series of two courses for Optics students dealing with basic physics. computer programming. The goals for this first course is to learn the calculus-based general physics as the foundation for any other courses in Dept of Photonics Engineering. 本課程協助光電工程學系學生建立其他學科之物理基礎, 做為高中學科與大二、大三、大四的專門學科（如電磁學、半導體物理、光學、近代物理）的橋樑。授與學生以微積分為基礎的普通物理課程, 著重基本原理以及例題的演算。

The teaching format is 0) Review of selected problems from previous chapters, 1) Introduction: Animations from Physclips (or other animations) to give overview 2) Following the textbook, the lectures focus on principles as well as example applications, and 3) Students learn the physics in depth by doing *extensive homework* on-line! 以課本為主軸，在課堂上講解原理，輔以例題。學生自己在作習題時從中領會物理的精要。

The key topic we will study are listed below in Table 1.

Table 1: Key Topics in this course

#	Topic	題目	Details	
1	Measurement	量測	standard units of measurement, precision, order of magnitude estimates	介紹度量衡單位標準之制定、有效位數、數量級估計)
2	Kinematics	運動學	Vector, displacement, velocity, acceleration, differential, projectile motion, circular motion, relative motion	向量、位移、速度、加速度、微分、拋體運動、圓周運動、相對運動
3	Newtonian dynamics	牛頓力學	Newton's three laws of mechanics, trying to show, surface gravity, elasticity, tension, normal force, mass and weight, friction, pulleys and ropes,	牛頓力學三大定律、示力圖、地表重力、彈力、張力、正向力、質量與重量、摩擦力、滑

#	Topic	題目	Details	
			centripetal force, false force	輪與繩、向心力、假力
4	Linear momentum	線性動量	impulse, linear momentum, conservation of linear momentum, collisions (elastic, inelastic, perfectly inelastic), a two-dimensional collision	衝量、線性動量、線性動量守恆、碰撞(彈性、非彈性、完全非彈性)、二維碰撞
5	Energy	能量	Kinetic energy, power, integration, vector product, power, power - energy principle, surface gravitational potential energy, elastic potential energy, conservative forces, conservation of mechanical energy, potential energy - position and force curve	動能、功、積分、向量內積、功率、功-能原理、地表重力位能、彈力位能、保守力、力學能守恆、位能-位置曲線與力之關係
6	Rotation	轉動	Rigid, centroid, rotation motion, rotational kinetic energy, physical integration, moment of inertia, torque, static equilibrium, scroll, vector outer product, angular momentum, conservation of angular momentum	剛體、質心、轉動運動學、轉動動能、體積分、轉動慣量、力矩、靜力平衡、滾動、向量外積、角動量、角動量守恆
7	Oscillation	振盪	Harmonic oscillations, transverse spring oscillator, the relationship oscillation with a circular motion, the simple harmonic oscillation of energy conversion, simple harmonic oscillation of the equation of motion (simple differential equations description), vertical spring oscillator, pendulum, physical pendulum, damped oscillations, driven oscillation resonance	簡諧振盪、橫向彈簧振子、振盪與圓周運動之關係、簡諧振盪之能量轉換、簡諧振盪之運動方程式(簡易微分方程式介紹)、垂直彈簧振子、單擺、物理擺、阻尼振盪、驅動振盪、共振
8	Waves	波	Longitudinal and shear waves, the basic parameters (wavelength, frequency, velocity, amplitude, phase), the energy and power delivery, the wave equation, the superposition principle, interference, the amount of phase transfer intensity standing wave resonance, sonic, pressure waves, sound and volume, tone, beat, Doppler effect	縱波與橫波、基本參數(波長、頻率、波速、振幅、相位)、傳遞的能量與功率、波方程式、疊加原理、干涉、相量、駐波、共振、聲波、壓力波的傳遞、聲音的強度與音量、樂音、拍頻、都卜勒效應
9	Thermodynamics	熱力學		
A	Traveling Waves	傳遞波		

0.5 Calendar/Course Schedule

The times on this calendar are tentative and may be changed depending on students' progress.

Table 4: Course Plan and Time Table

Wk	Topic	Chapters	Test Date
1	introduction; ch1 concept of motion; ch2 kinematics in 1D	1,2	
2	ch2; ch3 review of vectors; ch4 kinematics in 2D	3,4	
3	ch4; ch5 force and motion; ch6 dynamics I—motion in 1D	5,6	
4	ch6; ch7 Newton's third law; ch8 dynamics II: motion in 2D	7,8	
5♦	ch8; Review chapter 1 - 8 Challenge #1 (Newton's Laws)		Thursday, October 16, 2014
6	ch9 impulse and momentum; ch10 energy;	9,10	
7	ch11 work; Review Chapter 9,10,11	11	
8♦	Challenge #2 (Conservation Laws 9-11) ch 12: Rotation of a Rigid Body	12	Wednesday, November 5, 2014
9	midterm break - no class.		
10	ch14 Oscillations ch15 fluids and Elasticity (Optional)	14,15	
11♦	Review Chapter 12,14,15 Challenge #3 (Oscillations, Rotations, Fluids and Elasticity)		Thursday, November 27, 2014
12	ch20 Waves (Travelling Waves)	20	
13	ch21 Waves (Superposition)	21	
14	ch22 Waves (Optical)	22	
15	ch23 Ray Optics	23	
16	Review Chapter 20,21,22,23 HOLIDAY		
17♦	Challenge #4 (Waves) ch 38 Quantization (Optional) ch 39 Wave Functions and Uncertainty (optional)	38,39	Wednesday, January 7, 2015
18	final exam week -- no class		

0.6 Grading

Table 2: Milestones and Their Weight for Midterm and Final Assessments

項目編號	項目名稱 Milestone	期中評量權重 Midyear	學期總成績權重 Final
1	Newton's Laws	X	X
2	Conservation Laws	X	X
3	Oscillations, Rotations, Fluids and Elasticity		X
4	Waves		X

In addition there will be an additional 15% assigned for homework and 10% for in-class performance. Your mark will be calculated using the following equation:

$$Final = 0.30 \times M_{top} + 0.20 \times M_{2nd} + 0.15 \times M_{3rd} + 0.10 \times M_{low} + 0.15 \times HS + 0.10 \times CL$$

Consider, for example, the student Xiaoming with the grade in the table 3. On the one hand, since Milestone 1 was Xiaoming's best test, it is given a heavy weight in calculating his final results.

On the other hand, he did poorly on Milestone 2, so it is given a very light weight in calculating this student's final results. Finally the points awarded for each milestone are added up with the result at Xiaoming receives a B grade on the course.

Table 3: Sample Final Grade calculations for Xiaoming

項目編號	項目名稱 Milestone	Grade (G)	Weight (W)	Points = G*W
1	Newton's Laws	90%	30%	0.27
2	Conservation Laws	20%	10%	0.02
3	Oscillations, Rotations, Fluids and Elasticity	70%	20%	0.14
4	Waves	50%	15%	0.08
-	Homework Score (HW)	80%	15%	0.12
-	In-class Performance Score (CL)	75%	10%	0.08
FINAL				70%

Similarly for the midterm grade the calculation proceeds similarly but since only two milestones have been tested, the calculation weighting is defined by:

$$Midterm = 0.50 \times M_{top} + 0.25 \times M_{low} + 0.15 \times HS + 0.10 \times CL$$

1. Organizing a Solution – Algorithms, UML Activity Diagrams

1.1 Algorithms

a. Definition

An algorithm describes the steps that one needs to take to take in order to perform a certain task or computation. On the one hand, the same algorithm may be expressed in many different languages and still be the same algorithm even though it may look quite different. On the other hand, different algorithms can be used to perform the same task.



Fig. {muffin} Snickerdoodle Muffin*

More formally, an algorithm is defined as:

A finite sequence of steps,
- each step consisting of a number of operations,
- each operation
 1. is rigorously defined and unambiguous
 2. can be executed by a machine

b. Example: An algorithm to make muffins

A recipe is an example of an algorithm that describes how to prepare a specific dish or meal. Consider for example the following algorithm that describes how one makes muffins*.

1. Prepare ingredients: 2 cups flour, 1 tsp baking powder, 5 tbsp milk powder, 1 egg, 1/2 cup olive oil, 1 cup water
2. Turn oven on to 250 C.
3. Mix wet ingredients (water, olive oil, egg)
4. Mix dry ingredients (milk powder, flour, baking powder)
5. Pour wet ingredients into dry ingredients.
6. *(Option: Add 1 cup of fruit (i.e. blueberries) into batter.)*
7. Mix leaving a few lumps in the batter
8. Pour batter into muffin tray.
9. Bake in oven for 20 minutes
10. *If brown (finished cooking), GOTO Step 12*
11. *Bake for 1 more minute. GOTO Step 10*
12. Take out of Oven

This recipe explains the steps one follows to make muffins. It provides all the information that one needs to know to be successful. The new cook does not need to rediscover anything. Ignoring steps 6, 10, and 11 (in italics), the flow is seen to be linear – no decisions to make. Step 6 is a conditional or option – a decision needs to be made about whether to add berries to the muffin. Steps 10 and 11 indicate repetition: they need to be performed a number of times until a condition is met. As a final note, notice that the order in which steps 3 and 4 are completed is not important – in fact, they could be done in parallel. In the following section we will introduce UML activity diagrams that allow us to illustrate diagrammatically this algorithm.

* <http://eatathomecooks.com/2010/05/snickerdoodle-muffins.html> (Downloaded picture on 2014.04.16)

1.2 UML Activity Diagrams

a. Overview

Expressing your algorithm clearly before starting to write computer code is crucial for creating easy to understand, well structured code. In order to help you to do this, a standard, called Universal Modelling Language, UML for short, has been developed to help you learn to think before you start to code. (In the past we have used UML state diagrams to represent FSAs, now we will use UML activity diagrams to represent algorithms. If you have done programming before, you may have made use of a flowchart to represent an algorithm. The UML Activity diagram replaces a traditional flowchart.

Figure {UML} summarizes the key symbols that are used in UML activity diagrams. These diagrams are used to help us to show the steps in an algorithm. Fig. {UML} (a) identifies the symbols while Fig. {UML} (b) uses these symbols to describe the process are placed together to describe an algorithm to take the absolute value of a arbitrary number.

UML activity diagrams generally make use of five different symbols to represent Start, End, Activity (i.e. verb), Comment, Branch or Merge and three different types of lines to represent Transitions (solid lines with arrows), connect comments, and finally indicate Parallel processes. Within a given UML diagram, there should only be one start symbol. Activities are conducted in the order they appear in the diagrams. In the case that order is not important for two activities, then one can use the Parallel bar to indicate this. Fig. {UML} (b) shows how one can diagram an algorithm that returns the absolute value of a number. The the algorithm starts with a number (x) (indicated in comment box as a start condition.). Next a decision is made: if $x > 0$ then we take the right path. If $x < 0$ we take the left

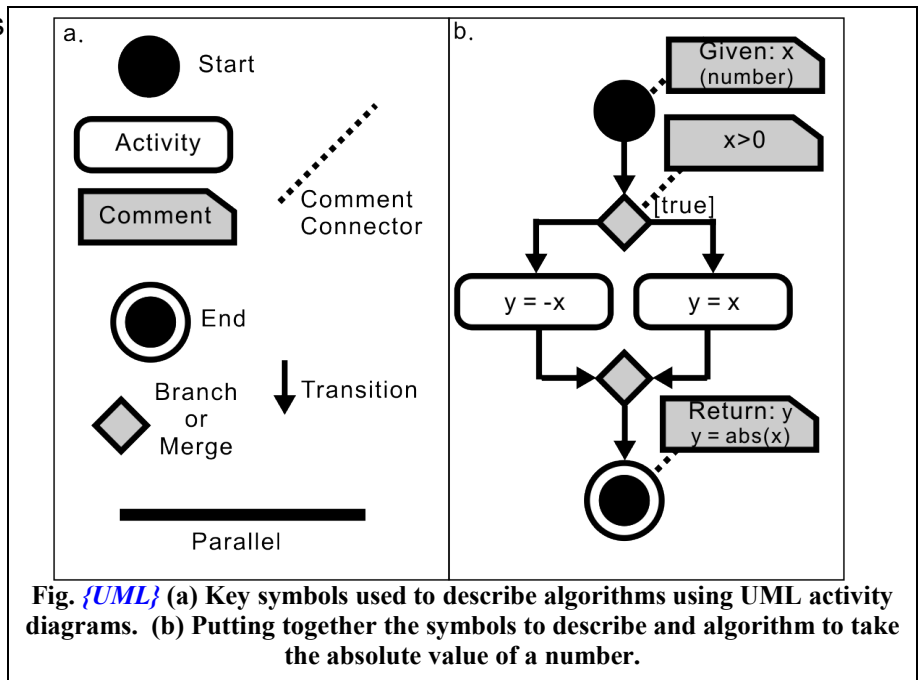


Fig. {UML} (a) Key symbols used to describe algorithms using UML activity diagrams. (b) Putting together the symbols to describe and algorithm to take the absolute value of a number.

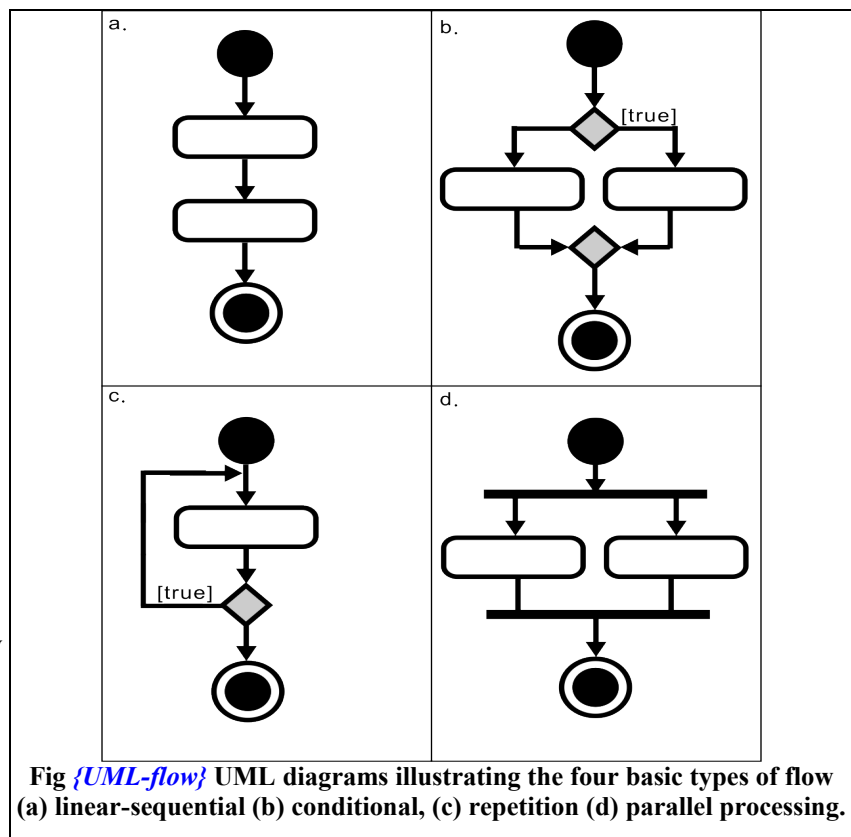


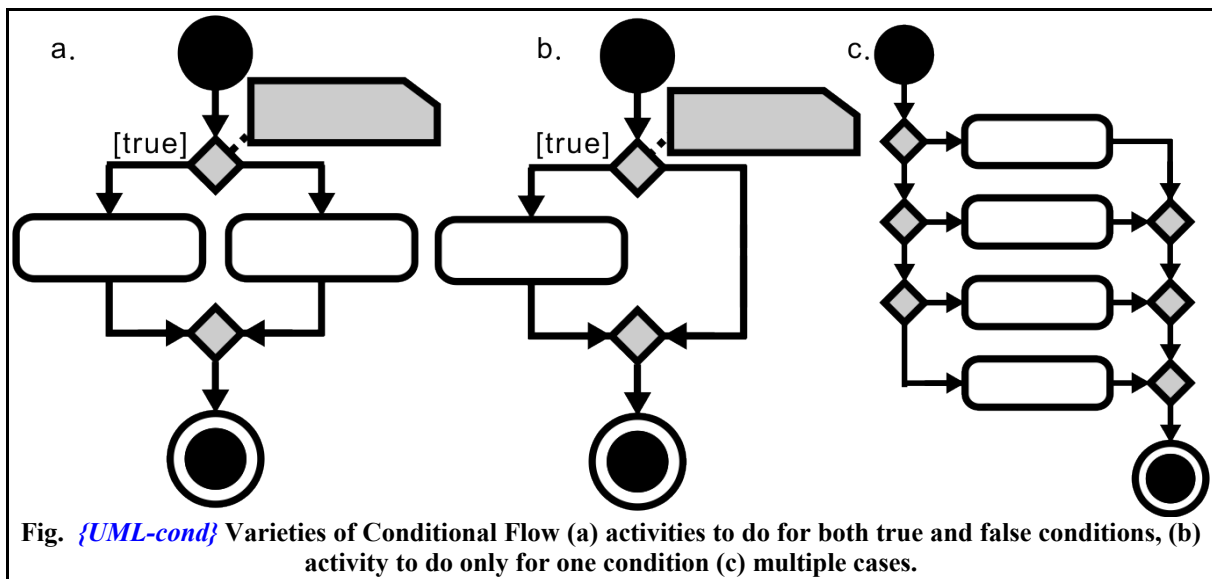
Fig {UML-flow} UML diagrams illustrating the four basic types of flow (a) linear-sequential (b) conditional, (c) repetition (d) parallel processing.

path. In the case that we take the right path, we just store the value of x in the variable y . In the case that we take the left path, we negate x and store the result in y . The paths then join back together (merge symbol) again and the algorithm ends. Note that if we take the right path, then we do not take the right path.

Figure *{UML-flow}* illustrates the four types of flow that can be implemented in a program. All algorithms can be expressed in terms of a combination of these flow structures. In Fig. *{UML-flow}* (a) linear-sequential flow is illustrated. In this type of flow, the activity in the upper box is first completed and then activity in the next box can be started. In (b) conditional flow is illustrated. Based on the the value of a variable or some condition either the right path is taken or the left path is taken. Both paths are never taken. Note that the diamond at beginning of the condition represents splitting of program flow while the diamond at the end represents a merging of the flow streams. In Figure *{UML-flow}* (c) illustrates repetition. In this type of flow, a given activity is repeated until some condition is met. Note that there is only one diamond representing the test condition and that the transition line pointing back ends on a transition line (not an activity box) Finally in (d) a specialized type of flow is illustrated: “parallel” processing. In this case, both activities are completed but the order in which they are completed is not important. Thus they can be done in parallel. In contrast to sequential processing, there is no order for activities. In contrast to conditional processing, both branches are taken. Parallel processing is denoted by a thick lines that mark both the beginning and end of the parallel activities.

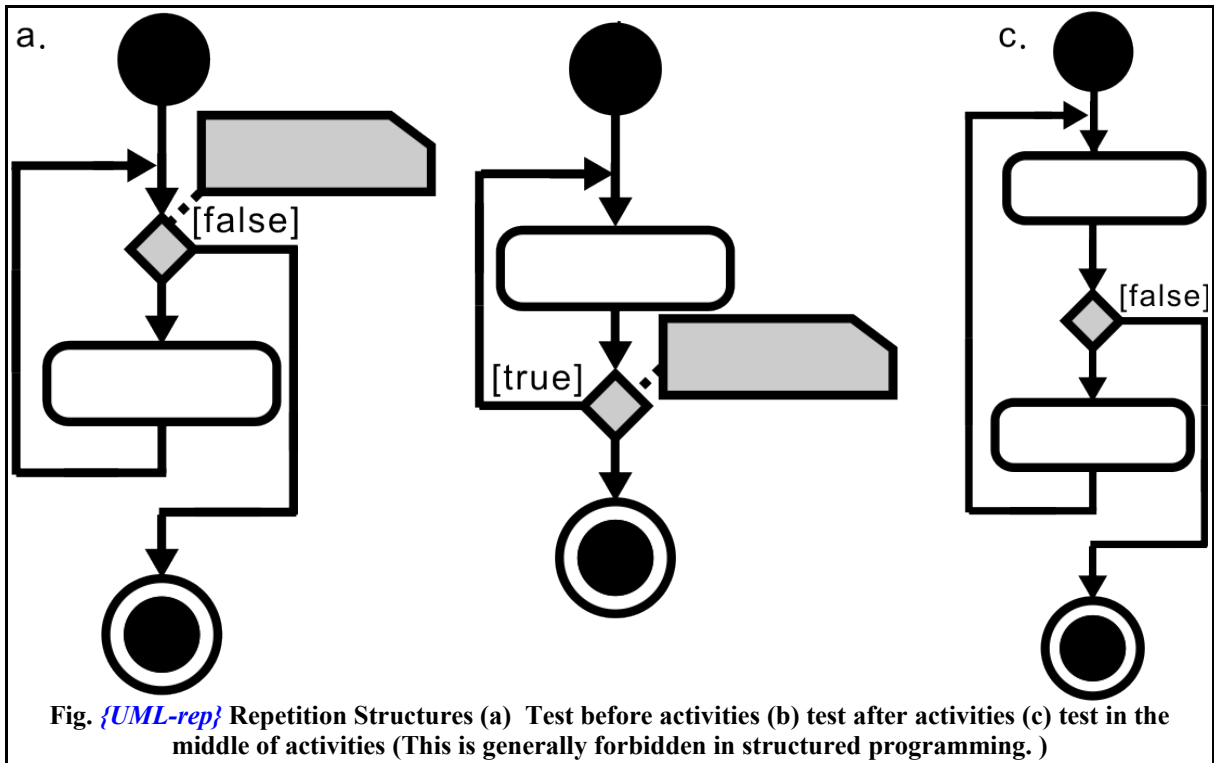
b. Conditional Flow

In structured programming, conditional flow is generally structured in one of the three ways shown in Fig. *{UML-cond}*. In each case comment boxes can be used to represent the condition to be tested. If the condition is very simple, then it can just be written on a line leaving the split symbol.



In (a) we illustrate the structure if an action needs to be preformed no matter what the outcome of the check. (b) represents the condition that we only need to preform an action if something is true or false. For example, in our function to calculate absolute value of x , if we didn't want to create a new variable y but rather keep only one variable x , then we need do nothing in the positive case. Finally (c) represents a situation when we do different things in many different cases. For example, a function that based on the maximum education received by an individual preforms a different actions. In this case, on might process data based on whether the individual has graduated from university, high school, primary school or has received no formal education.

c. Repetition

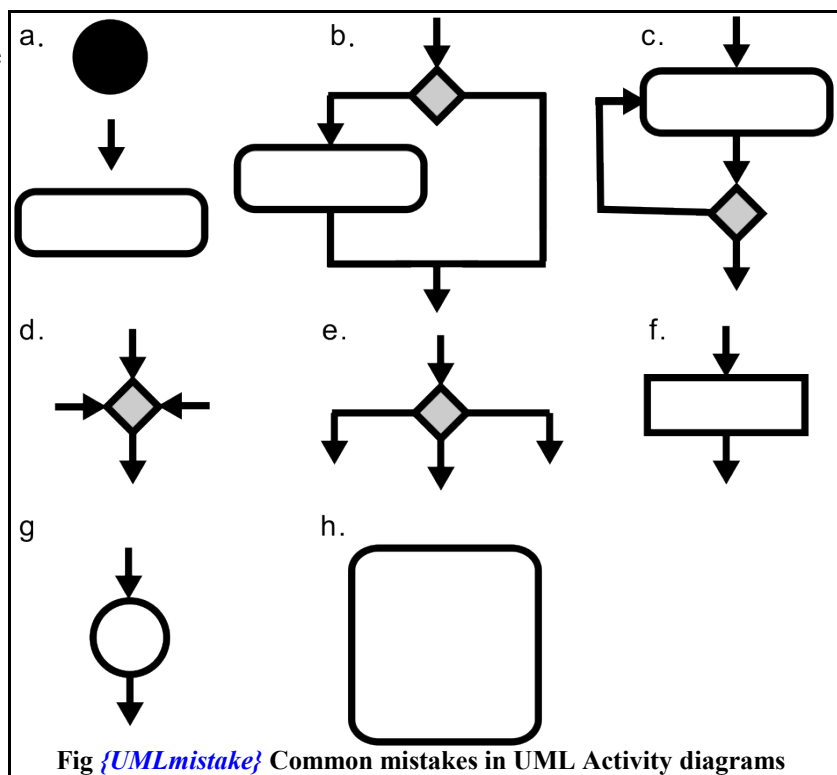


In structured programming, repetition is generally structured in one of the two ways shown in Fig. {UML-rep}. Figure {UML-rep}(a) represents the case in which the condition is tested before the loop any activity is completed while (b) represents the case that the condition is tested after the activities have been completed one time. The key difference is that, in the first case, it is possible for the activities within the loop never to be executed. Finally (c) represents the condition that the looping condition is tested in the middle of the loop. In structured programming this type of

structure is forbidden as it makes code difficult to read. Note that the condition, if complicated, is written in a comment box and one transition is labelled as [true] or [false]. Alternatively, if the condition is simple we can write it on one of the transitions lines.

d. Common technical drawing mistakes

Other than logic, there are a number of common technical mistakes that are often made in drawing these types of diagrams. These are illustrated in Fig. {UMLmistake}, namely, arrows not connected to anything (a), skipping the merge icon on conditionals (b), feeding back into an activity box (c), multiple inputs into a merge box (OK in special

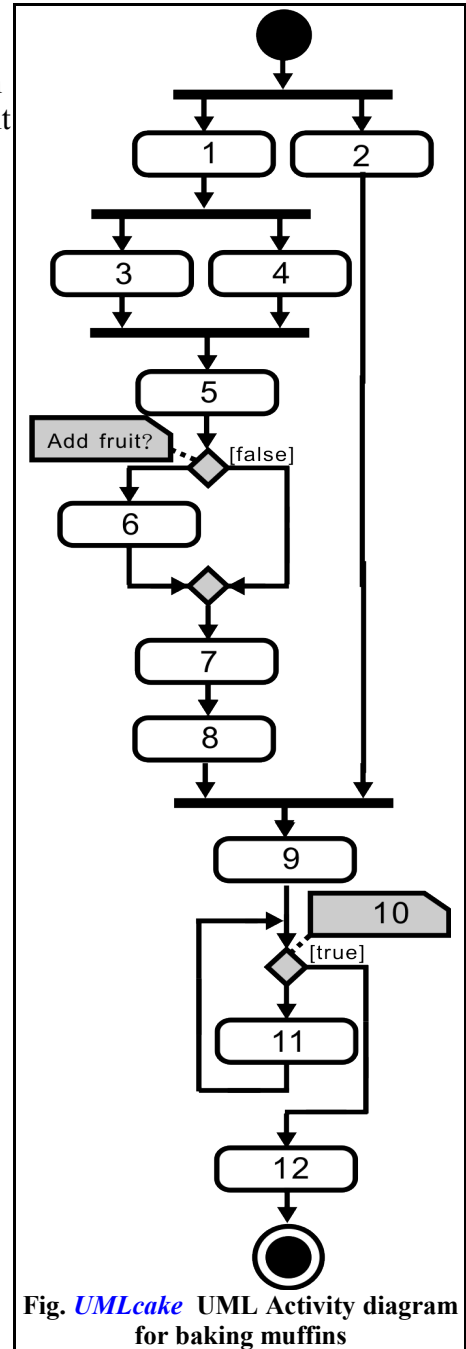


cases) (d) , multiple exits from a split symbol (OK in special cases) (e), non-rounded rectangles (f), and circles (g). Non-rounded rectangles are used in structural UML diagrams (not activity UML diagrams) to represent classes and circles are used in Finite State Diagrams. Finally in (h) we demonstrate the mistake of putting a number of different steps all in one box or using complicated English to describe a process (not machine executable). Each step should have its own box in an activity UML diagram.

1.3 Example: UML for Baking Muffins

As a final example of UML, we will convert our baking recipe to UML Activity diagrams, For simplicity in the example, just the step number is written in the activity boxes or comment box. The diagram makes it quite obvious that, at least at one point in time, at least three tasks can be done simultaneously. For example, I can have my youngest daughter, Liang-En doing step 3, Li-En doing step 4 and I can send my oldest daughter Aien warming up the oven.

1.4 Functions



2. Formalizing the problem solving approach

2.1 Problem Background and Statement

A number of old bombs have been unearthed in Gipuzko (cf Fig. {bomb}). These bombs have the shape of a hollow sphere. Your coworkers have compiled a list of the bombs found along with their weight, and inner and outer diameters. Write a program to calculate the density of the material used to make the bombs. (From the density, one can then try to guess the material used to make the bombs.)

2.2 Think

The first step is think about how to solve the problem, compile the equations needed (do a literature search if necessary) and attempt to solve the problem for a simple case.

2.3 Summarize and write as mathematical variables the information we have received:

d_{outer} : outside diameter of the spherical bomb

d_{inner} : inside diameter of the hollow shell

m : mass of the bomb

2.4 Compile (search for in the literature) the necessary equations.

Density (ρ) is related to mass (m) and volume (V) of the material by

$$\rho(m, V) = m/V \quad (1)$$

From basic geometry, the volume of a solid sphere can be related to its diameter (d) by the expression as:

$$V_{\text{sphere}}(d) = \pi d^3/6 \quad (2)$$

The volume material of the hollow shell can be expressed as the difference in volumes of an outer and inner sphere:

$$V_{\text{hollowShell}}(V_{\text{outer}}, V_{\text{inner}}) = V_{\text{outer}} - V_{\text{inner}} = V(d_{\text{outer}}) - V(d_{\text{inner}}) \quad (3)$$

2.5 Do a simple hand calculation

Having assembled the required equations, we can then make a sample calculation with some simple numbers. For example,

$$d_{\text{outer}} = 20 \text{ cm}$$

$$d_{\text{inner}} = 10 \text{ cm}$$

$$m = 30 \text{ kg}$$

First we calculate the volumes of the outer sphere and the inner hollow region:

$$V_{\text{outer}}(d_{\text{outer}}) = \pi d_{\text{outer}}^3/6 = \pi 20^3/6 = 4000\pi/3$$

$$V_{\text{inner}}(d_{\text{inner}}) = \pi d_{\text{inner}}^3/6 = \pi 10^3/6 = 1000\pi/6$$

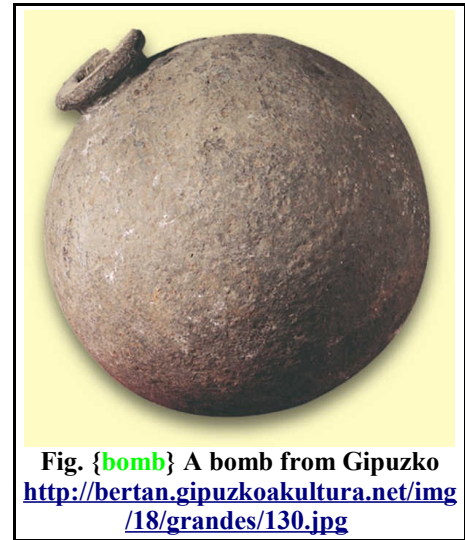
From this we can estimate the total volume of material in the bomb:

$$V_{\text{hollowShell}}(V_{\text{outer}}, V_{\text{inner}}) = V_{\text{outer}} - V_{\text{inner}} = 4\pi/3 - \pi/6 = 7000\pi/6 \sim 3660 \text{ cm}^3$$

and finally the density of the material used to make the bomb casing

$$\rho(m, V) = m/V = 30000 \text{ g} / 3660 \text{ cm}^3 \sim 8 \text{ g/cm}^3$$

We can then compare this density with normal density of materials. From Wikipedia we can look up the densities of a number of materials: (Aluminum, 2.643. Brass, 8.553. Cobalt, 8.8.



Copper, 8.9. Gold, 19.32. Ice, 0.897. Iron, 7.86. Lead, 11.37 g/cm³) Our result is closest to that for Iron and so we conclude that probably this bomb shell is made predominately from Iron with maybe the addition of some Lead.

2.6 UML diagram

Once we have worked through a sample problem, the next step is to summarize our algorithm using a UML diagram.

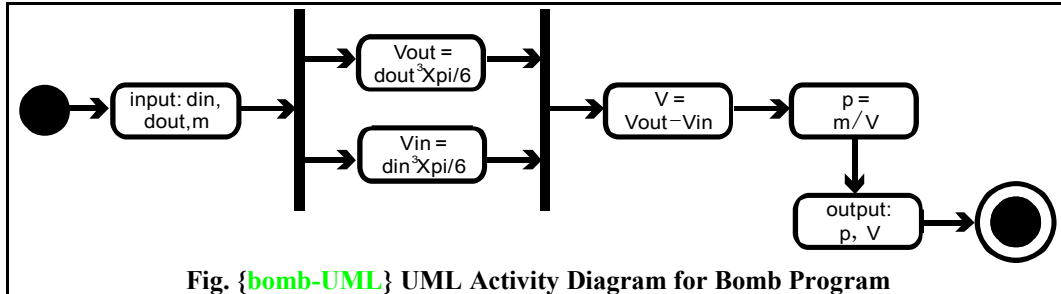


Fig. {bomb-UML} UML Activity Diagram for Bomb Program

In the above diagram, we can see that the first step is to get the required information from the user. Next we calculate both the inner and outer volumes for the spherical shell. Since order is not important, we draw these steps in parallel (note that these both use the same function with different inputs). This is followed by the calculation of the total volume of material in the bomb, followed by the density of the bomb. Note that these steps must follow in order, i.e., we cannot calculate the density of the bomb until we have calculated the total volume of material in the bomb. We cannot calculate the total volume of material until we have first calculated the inner and outer volumes.

3. Assignment Questions by Chapter

All questions are due completed on Tuesday of the week following their introduction in the class. The following is an estimated timeline...

Wk	Chapters	Start Date	Due Date
1	0,1,2	2014-09-17	2014-09-23
2	3,4	2014-09-24	2014-09-30
3	5,6	2014-10-01	2014-10-07
4	7,8	2014-10-08	2014-10-14
5♦			TEST
6	9,10		
7	11		
8♦	12		
9			TEST
10	14,15		
11♦			TEST
12	20		
13	21		
14	22		
15	23		
16♦			TEST
17	38,39		
18			

4. Notes by Chapter

4.1 Chapter 1

4.2 Chapter 2: Kinematics

a. Question: Santa Claus on my roof

Santa Claus has landed on the top of my roof in Canada. Due to the large amount of ice on the roof, he starts to slide down the roof. (1) Determine the velocity at which Santa Claus hits the ground using kinematic equations. (2) Determine the horizontal distance which Santa Clause travels before he hits the ground. Will he bump into the neighbour's house?

b. Picture and motion diagram (Fig. 1(left))

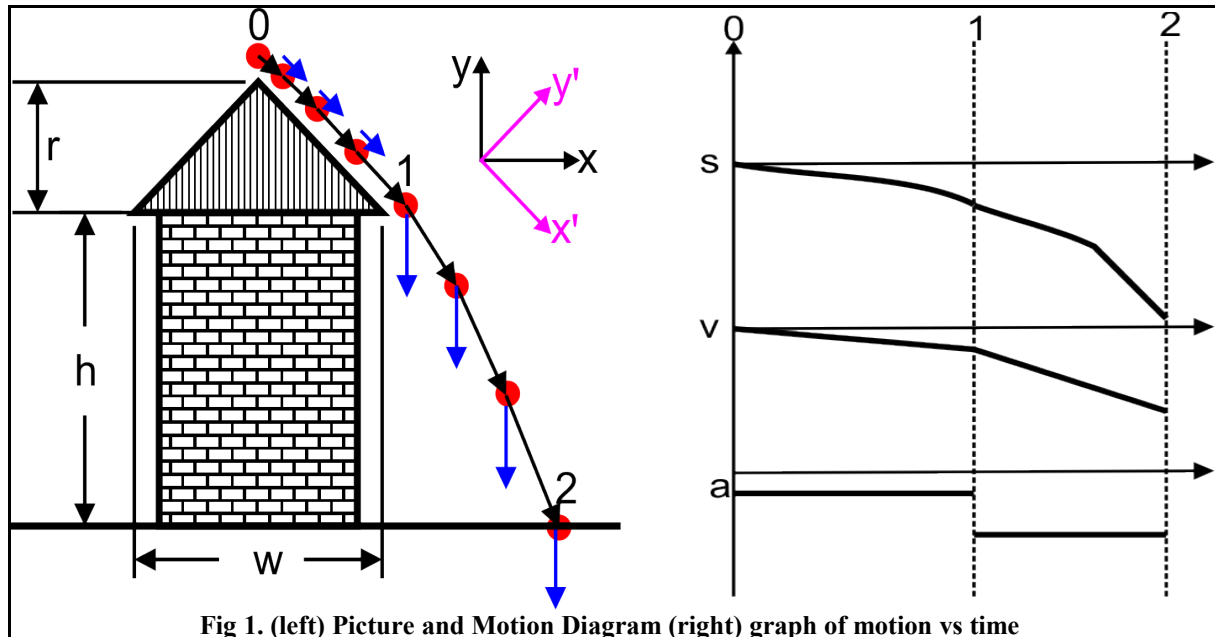


Fig 1. (left) Picture and Motion Diagram (right) graph of motion vs time

c. Graph of Motion (Fig. 1 (right))

d. Data from maps.google.com : 129 Wentworth St. North, Hamilton ON.

$$h=6\text{ m}, w=5\text{ m}, r=2.5 \rightarrow \beta=\pi/4\text{ rad},$$

$$a=0.5\text{ m (distance between houses).}$$

e. Key observations

- i. Acceleration is constant with two values.
- ii. We don't care about time.
- iii. starting velocity and distance is zero
- iv. Use two coordinate systems (first one parallel to roof, next vertical)

f. Solution in symbols and with math:

1. We don't care about time, so we first look at the roof using a slanted 45 degree coordinate system with the x axis in the direction of motion

$$v_{1x}^2 = v_{0x}^2 + 2a\Delta x$$

$$\rightarrow v_{1x} = \sqrt{2g\sin(\beta)} \sim 3.7 \frac{m}{s},$$

$$\rightarrow \vec{v}_1 = 3.7\hat{i} + 0\hat{j}$$

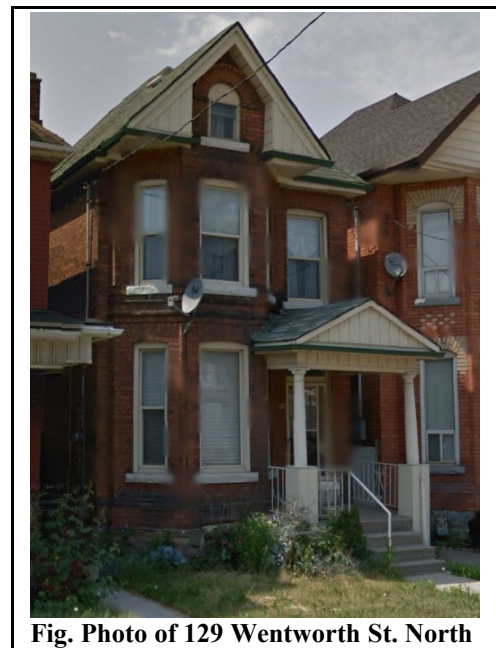


Fig. Photo of 129 Wentworth St. North

2. Next we can change to a vertical coordinate system (Rotation of 45 degrees)

$$\vec{v}_1 = 3.7 \text{ m/s}, \theta = -\pi/4$$

$$\vec{v}_1 = 2.7 \hat{i} - 2.7 \hat{j} \text{ [m/s]}$$

3. Now in the free fall, the horizontal speed will be unchanged but gravity will affect the vertical component.

$$v_{2y}^2 = v_{1y}^2 + 2a \Delta y = (2.7 \text{ m/s})^2 + 2 \times 10 \text{ m/s}^2 \times 6 \text{ m} \rightarrow v_{2y} = -11.3 \text{ m/s}$$

4. Thus we can write the final velocity as...

$$\vec{v}_2 = 2.7 \hat{i} - 11.3 \hat{j} \text{ [m/s]} \equiv (11.6 \text{ m/s}, \theta = 0.23 \text{ rad} (13.4^\circ))$$

g. Assess. We would like to check the reasonableness of the data. If we can find the solution another way then can verify. Lets use energy method (later chapter)

$$mgh = mv^2/2 \rightarrow |\vec{v}| = \sqrt{2gh} = \sqrt{2 \times 10 \times 8.5} = \sqrt{170} \sim 13 \text{ [m/s]} \text{ (similar, so OK)}$$

h. Now we might like to know the horizontal distance travelled by Santa Claus and the time he has to consider his fate as he falls.

1. On the roof: $v_{1x} = a \Delta t \rightarrow \Delta t = v_{1x} / (g \sin(\beta)) = 4\sqrt{2}/10 = 0.56 \text{ s}$

2. In the free fall: $v_{2y} = v_{1y} + a \Delta t \rightarrow \Delta t = (v_{2y} - v_{1y}) / g = (11 - 2.8) / 10 \text{ s} = 0.8 \text{ s}$

3. Therefore the horizontal distance travelled by Santa Claus is

$$d_{2x} = d_{1x} + v_{1x} \Delta t = 2.5 + 2.8 \times 0.8 \sim 5 \text{ m} \text{ (uniform horizontal motion)}$$

Looking at the Google Maps of the house, it is clear that Santa Claus will bump into the neighbouring house before he hits the ground! In fact, if he is falling near the back of the house, he will probably land on the neighbours roof!

4.3 Chapter 3

4.4 Chapter 4

4.5 Chapter 5: Forces

At this point we have now starting physics!

Mechanics	
<p>Kinematics (How?) Observe... Ch 1 - 4 $\bar{v} = d\bar{r}/dt$ $\bar{a} = d\bar{v}/dt$ Circular... $\omega = d\theta/dt$ $\alpha = d\omega/dt$</p>	<p>Dynamics (Why?) Think (physics) Ch 5 - 8 $\bar{a} = \frac{1}{m} \bar{F}_{net}$</p>