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Revising the Student Experiment Materials and Practices at the National University of Laos

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***Abstract*—**The National University of Laos (NUOL) invited a group of volunteers from the Japan International Cooperation Agency (JICA) to revise the physics experiments to utilize the materials that were already available to students. The intension was to review and revise the materials regularly utilized in physics class. The project had access to limited materials and a small budget for the class in the unit; however, by developing experimental textbooks related to mechanics, electricity, and wave and vibration, the group found a way to apply them in the classroom and enhance the students teaching activities. The aim was to introduce a way to incorporate the materials and practices in the classroom to enhance the students learning and teaching skills, particularly when they graduate and begin working as high school teachers.

***Keywords*—**NUOL, JICA, physics experiment materials, small budget, mechanics, electricity

I. IN.TRODUCTION

THERE are many fields in teaching physics. Physics experiment materials are available, but they are old, and the authors have almost no experience in using materials related to mechanics, electrostatics, electricity, electromagnetics, alternating electricity, and optics fields that are available in the physics unit in the Department of Natural Science, Faculty of Education at NUOL. The group has the task of updating these outdated experiment materials and practice experiments with the students in the physics class. In the physics teaching process, it is important to understand the concepts and their use in everyday life. When performing experiments, it is important to pay attention and review what was learned.

The volunteer group in this paper has minimal experience of teaching an experiment class; however, the intention is to develop a simple textbook that is easy to understand and encourages students to create their own experiments. The goal is to make use of the materials already available. Each page of the experiment textbook will outline an exercise. Students are encouraged to discuss the details of the experiment with each other and after class, in order to understand together.

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II. TEXTBOOKS OF REVIVED MATERIALS

The materials that were stored in the laboratory staff room were moved to the new physics prep room. Most of the materials were covered with dust. The first step was to clean and check each item to determine if they could still be used or not. The department purchased the materials almost 20 ago, and most of the original manuals were missing, so it was necessary to search for each item one by one and develop the necessary materials and manuals.

1. Mass Measurement

- Purpose: To understand mass and learn how to use a triple beam balance.
- Materials: Triple bam balance, balance weight, mass objects.
- Procedure:

1. Set each beam balance zero respectively.
2. Check the top of the beam indicates zero. If not, adjust the nut under the plate by rotating it.
3. Put the sample weight on the plate and measure the weight beginning from the heavy weight scale beam. Record the results in Table I.

TABLE I
MASS MEASURE

Sample weight 10^{-3} [kg]	1	2	3	10	20	30	50	100	200	500
Weight [kg]										

Only one balance is available for use. This balance has a loading disk and three kinds of scale weight beams. It is easy to use, but it is very important to treat the equipment gently.

2. Length Measurement with a Micrometer

- Purpose: To learn how to use the micrometer.
- Materials: Micrometer, paper [3].
- Procedure:

1. Release the lock.
2. Open the pinching edge and pinch what is to bemeasured.
3. Read the main gauge. If the main gauge is less than half, take the reading from the sub gauge directly.
4. Set pinch arm open.
5. Release the lock of the micrometer and pinch the paper and check the tightness using the end screw. Be careful to ensure it is not tight too much or too lose.
6. Read the measurement on the main scale and subscale. Record the results in Table II.

TABLE II
LENGTH MEASURE MICROMETER

Sample paper	1	2	3	10	20	30	50	100	200	500
Length [m]										

It is important, for example, to read the thimble where it screwed out so that the graduation 5, and one additional 0.5 subdivision were visible on the sleeve, and that the graduation 28 on the thimble coincided with the axial line on the sleeve. Thus, the reading would then be 5.00 + 0.5 + 0.28 = 5.78 mm.

3. Length Measurement Using Calipers

- Purpose: To learn how to use calipers.
- Materials: Vernier caliper, paper, pipe, hole [4].
- Procedure:

1. Release the lock.
2. Open the outside pinching edge and pinch what to measure. Open the inside pinching edge and pinch inside of the pipe. Stretch the depth inserting rod into the hole.
3. Read the main gauge. Read the sub gauge and align the main gauge. Set pinch arm open.
4. Release the lock on the caliper and pinch the paper and read the main gauge, then read the Vernier reading that coincides with the main gauge.
5. Read the main scale gauge and the Vernier gauge. Record the results in Table III.

TABLE III
LENGTH MEASURE CALIPER

Sample	1	2	3	10	20	30
Paper [cm]						
Pipe inside[cm]						
Hole depth[cm]						

It is difficult to find the coinciding point with main gauge mark line and subgauge mark line. For example, how to read value of Vernier Calipers if the number zero of the calipers is between 9 mm and 10 mm, on the main gauge the length about 9 mm and on the Vernier Caliper is 1.5 mm, the same as the dot on main gauge from number zero although the device point has three points, so that 3 X 0.05 mm = 0.15 mm, then the length for measurement is (9 + 0.15) mm = 9.15 mm. Reading the subgauge follows written value into the table.

4. Mass Measurement by Balance 1

- Purpose: To measure mass and to learn how to use the balance 1.
- Materials: rod, strings, known weight, ruler [7].
- Procedure:

1. Search the mass center of a rod.
2. Tie a string to the center of the rod.
3. Hang a 1-kg weight on the right side and the material to measure on the other side.
4. Measure the lengths of both sides.
5. Calculate the weight from the length ratio of weight.
6. Tie the string with the hanger.
7. Catch string on the above of the hanger.
8. Adjust to find the balance point of the 1-kg weight hanging on the other end of the rod. Record the results in Table IV.

TABLE IV
MASS MEASURE BALANCE 1

Hanging length of 10^{-2} [m]	30	30	30	30
Length of 1kg 10^{-2} [m]				
Weight W 10^{-3} [kg]				

The rod is handmade from bamboo and must be gripped at the center to correctly determine the balance point.

5. Mass Measurement by Balance 2

- Purpose: To measure mass, and to learn how to use the balance 2.
- Materials: Rod, string, a known weight, ruler [11].
- Procedure:

1. Set a hanging point of the rod.
2. Tie the string to the hanging point and hanging material with a bag to the rod (for example, 5×10^{-2} m).
3. Hang the material to measure and search for the balance point of 1 kg.
4. Measure the lengths of the 1-kg weight.
5. Calculate the weight from the length ratio of weight.
6. Set the hanging point with the string and bag.
7. Hang the material on the bag.
8. Search the balance point of the 1-kg weight hanging on the other side of the rod. Record the results in Table V.

TABLE V
MASS MEASUREMENT BALANCE 2

Hanging length of W 10^{-2}[m]	5	5	5	5
Length of 1kg 10^{-2} [m]				
Weight W [kg]				

This balance is also handmade, but the grip point is near the end of the rod.

6. Measure Gravitational Acceleration

- Purpose: To measure gravitational acceleration.
- Materials: String, frame hanging of a string, weight, ruler, stop watch [4].
- Procedure:

1. Set the hanging point of the pendulum.
2. Tie string to the hanging point and measure the length to the mass center of weight from the hanging point.
3. Set the pendulum swing center.
4. Measuring pendulum movement for 10 return swings.
5. Calculate the gravitational acceleration using the formula of simple pendulum motion as in the below and then record the value time of the period in Table VI.

$T = 2\pi\sqrt{\frac{l}{g}}$ or $g = 4\pi^2 \frac{l}{T^2}$. is equation being used for find gravitational acceleration

TABLE VI
GRAVITATIONAL ACCELERATION

Length of string l [m]	1.0	1.0	1.0	1.0	1.0
Time of 1 period T[s]					
Gravitational acceleration g [m/s^2]					

The hanging material available is inadequate, and therefore, attention must be paid to the time start-point and end-point.

7. Potential Energy Transformation to Kinetic Energy 1

- Purpose: To understand how to transform potential energy into kinetic energy.
- Materials: String, frame hanging a piece of string, a weight, a ruler [9], [11], [12].
- Procedure:

1. Set the hanging point of the pendulum, tie the string to the hanging point and measure the vertical length of the weight from the table.
2. Set the target ball on the table, lay the object down and tie with string from the height and collision with the mass set on the table, after collision each mass set on the table is going to fall from the table to the floor, then measure distance in the horizontal from the mass on the table and the mass on the ground.
3. Calculate the gravitational potential energy, calculate the speed of swinging ball at the strike point, and calculate the velocity of the ball at it strikes from the horizontal distance and vertical height from the table using the following equations:

Before collision: $mgh = \frac{1}{2}mv^2$, $v^2 = 2gh$

After collision: $x = ut$, $H = \frac{1}{2}gt^2$, $t^2 = \frac{2H}{g}$, $u^2 = \frac{gx^2}{2H}$

Record the results in Table VII.

TABLE VII
POTENTIAL ENERGY TRANSFORMATION TO KINETIC ENERGY

$\frac{1}{2}mv^2 = mgh[J]$
$\frac{1}{2}mu^2 = \frac{mgx^2}{4H}[J]$
$\frac{u}{v} = \frac{x}{2\sqrt{hH}}$

Compare the energy before collision and after collision and calculate the speed ratio by the horizontal length of flight and the vertical lengths.

8. Cone Pendulum

- Purpose: Measure the tension for rotation of a spring.
- Materials: Spring, weight, ruler, stop watch.
- Procedure:

1. Set a spring hanging from a frame, place a weight hanging from the spring and measure the length of the spring.
2. Calculate the spring constant, set the weight hanging from the spring.
3. Rotate the weight with the spring, measure the length of the spring, and measure the radius of the cone.
4. Measure the time period. Determine the measure of tension F of the rotation using the equation below:

$$T = 2\pi\sqrt{\frac{l\cos\theta}{g}} \; , \; F = \frac{4\pi^2 m\, l}{T^2}$$

Record the results in Table VIII.

TABLE VIII
CONE PENDULUM

Time of period [s]
Length of rope [m]
Mass of weight [kg]

It was not possible to make a cone pendulum using big string and heavy weight because the friction force between the holding pipe and the rope is too high, and therefore, the textbook was rewritten using a smaller size spring.

9. Measure a Spring Constant

- Purpose: To measure the spring constant.
- Materials: Spring, weight, ruler, stop watch,
- Procedure:

1. Set a spring hanging from a frame.
2. Place a weight hanging from the spring and measure the length of the spring.
3. Obtain the spring constant from the extension of the spring.
4. Set the weight hanging from the spring.
5. Pull the weight and swing the spring pendulum, measure 10 return swings, and
6. Determine the period of the pendulum and using the spring pendulum formula below, calculate the spring constant.

$$T = 2\pi\sqrt{\frac{m}{k}}, \; k = 4\pi^2\frac{m}{T^2}$$

Record the results in Table IX.

TABLE IX
MEASURE SPRING CONSTANT

Time of period [s]
Length of spring [m]
Mass of weight [kg]

In this case, it is easy to determine the spring constant from the weight; however, it is important to pay attention to the length used for the spring constant.

10. Acceleration of Motion of a Sliding Box on a Slope

- Purpose: To measure the acceleration of a box sliding down a slope.
- Materials: Paper, tape, timing bell, box, ruler, section paper, glue.
- Procedure:

1. Hang a long paper tape with the box, set timing bell.
2. Set up the box and place the tape through the recorder guide frame, incline the slope and switch the timer on.
3. Start the box down the slope and measure the angle of the slope.
4. Cut the tape and place at five intervals, put the cut tape on the section paper, measure the inclination of the graph formed with tape cut tips
5. Determine the acceleration of the box. Record the results in Table X.

TABLE X
ACCELERATION OF SLIDING BOX ON A SLOPE

Intervals	5	10	15	20	25	30	35
Time [s]	0.1	0.2	0.3	0.4	0.5	0.6	0.7
Length [m]							
Velocity [m/s]							
Acceleration [m/s^2]							

11. Acceleration of Free Fall

- Purpose: To measure the acceleration of free fall.
- Materials: Paper, tape, timing bell box, ruler, section paper, glue [9].
- Procedure:

1. Set a paper tape on the box, set the timing bell on the slope.
2. Place the box and set tape through the recorder guide frame, switch the timer on.
3. Drop the box.
4. Cut the tape and place at five equal intervals; put the cut tape on the section paper and measure the inclination of the graph formed with the tape.
5. Determine the acceleration of the box. Record the results in Table XI.

TABLE XI
ACCELERATION OF FREE FALL

Intervals	5	10	15	20	25	30	35
Time [s]	0.1	0.2	0.3	0.4	0.5	0.6	0.7
Length [m]							
Velocity [m/s]							
Acceleration [m/s^2]							

The two experiments above are designed to train students in using a timing bell. We have the carbon paper and get the white long paper tape.

12. Force Balance

- Purpose: To determine the force balance using gravity.
- Materials: Hanging stand, pulleys, string, known weight, ruler.
- Procedure:

1. Set the pulleys on the hanging frame, and pull the strings through the pulleys.
2. Hang a weight on the both end of the string, hang a determined weight on the string between the two pulleys.
3. Draw a picture of the forces on the paper, and check the balance of the force vectors. Record the results in Table XII.

TABLE XII
FORCE BALANCE

Hanging weight W1 [kg]	
Hanging weight W2 [kg]	
Hanging weight W3 [kg]	
Angle of two line [º]	

This experiment can be carried out once a pulley is brought to Laos, as cheap, small frictionless pulleys are not available.

13. Accelerated Motion on a Flat Desk

- Purpose: To confirm Newton’s Second Law.
- Materials: Experiment wagon, pulley, weight, timing bell, box, ruler, section paper, glue [9].
- Procedure:

1. Set the paper tape on the wagon, set the pecking machine of time recorder on the desk.
2. Set a pulley on the desk, set the thread on the wagon and pass it through the pulley and hung weights on other side.
3. Hold the weight and pull the wagon and tape through the recorder guide frame to the end of the desk.
4. Switch on the recorder, release the weight and measure the time and position of the wagon.
5. Cut the tape at five equal intervals, place the cut tape on the section paper, measure the inclination of the graph formed with the tape, and determine the acceleration of the wagon.
6. Change the mass above into a difference mass and then run the same experiment with the experiment above. Record the results in Table XIII.

TABLE XIII
ACCELERATION ON THE FLAT DESK

Intervals	5	10	15	20	25	30	35
Time [s]	0.1	0.2	0.3	0.4	0.5	0.6	0.7
Length [m]							
Velocity [m/s]							
Acceleration [m/s^2]							

This experiment is carried out using the same method as 10 and 11.

14. Collision and Momentum

- Purpose: To study collision and momentum.
- Materials: Standing frame, steel balls (3.15×10^{-2} m, 2.55×10^{-2} m diameter), and thread.
- Procedure:

1. Hang five steel, same mass balls by thread and parallel frames at the same length.
2. Free the balls so they move and can connect with each other.
3. Pull the first ball and to release with all the other balls remain still, and then release the ball and watch the result, for each ball make explain the result of each ball.
4. Pull two balls at the same time and release, and repeat procedure above.
5. Pull three balls at the same time and release, and repeat procedure above.
6. Pull four balls at the same time and release, and repeat procedure above. Record the results.

TABLE XIV
COLLISION AND MOMENTUM

Mass[kg]	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Time [s]							
Length [m]							
Velocity [m/s]							
Acceleration [m/s^2]							

15. Electrostatics

- Purpose: To study electrostatics from friction.

- Materials: Standing frame, insulator (glass, fur, silk, wood (paper), rubber, plastic film) 0.10 m length, iron wire, steel balls, thread, adhesive tape, plastic thread. Prepare a charging checker (electroscope). Tear a polyethylene thread into thin pieces (0.001 m × 0.010 m).
- Procedure:

1. Hang the threads on the stand, plus electric charge, minus electric charge, rub the transparent acrylic plate (glass) with the polyethylene film (silk), then the acrylic plate (glass) plus electric charges rub the gray vinyl chloride plate (ebonite) with paper (fur), then the vinyl plate minus electric charges.
2. Hang the glass, rubber, acrylic, iron rods using the adhesive tape from the horizontal rods, and then rub the acrylic plate and hanging rods with polyethylene film.
3. Hold the acrylic plate and draw it close to the rod. Record the reaction. Rub the vinyl chloride plate and hanging rods with the paper, then repeat the previous action and record the reaction. Record the results in Table XV.

The electrostatic experiment is sensitive, and therefore, attention needs to be paid to humidity or season. This experiment is best conducted in dry conditions.

TABLE XV
ELECTROSTATICS

Ball mass [kg]	
Length of thread [m]	
Distance [m]	
Electric charge [C]	

16. Coulomb's Law

- Purpose: To study Coulomb's Law.
- Materials: Iron stand, acrylic plate, polyethylene film, three steel balls (5 mm diameter), thread, adhesive tape, insulator stand.
- Procedure:

1. Set a steel ball on the top of insulator stand using adhesive tape, set up another ball by connecting a piece of thread to the ball and hang from the stand, hang the threads on the stand and ball electric charge.
2. Change the distance between two balls and measure the hanging ball distance from below. Record the results in Table XVI.

TABLE XVI
COULOMB'S LAW

Intervals	1	2	3
Distance A and B 10^{-3}[m]			
Distance O and B 10^{-3}[m]			

This experiment is difficult to carry out without suitable small spherical steel balls, which the laboratory lacks. This is also a very sensitive experiment.

17. Voltmeter and Ammeter

- Purpose: To learn how to use voltmeter and ammeter.
- Materials: Voltmeter, ammeter, power supply (12V DC), variable resistor (100 Ω), lead wire.
- The Procedure:

1. Setting the power supply, ammeter, and variable resistance in the series, and then connect the voltmeter with the variable resistance.
2. Set the DC power supply to on, change the resistance and measure the current and voltage. Record the results in Table XVII.

TABLE XVII
VOLTMETER AND AMMETER

Intervals	1	2	3	4
Voltage [V]				
Current [A]				
Resistance [Ω]				

This exercise teaches the basic usage of a volt meter and ammeter. Pay attention ammeter connection parallel to the circuit.

18. Electromagnet

- Purpose: To learn about electromagnets.
- Materials: Iron rod, coil (A: 600 turn, B: 400 turn, C: 200 turn), voltmeter, ammeter, power supply (12V AC), lead wire [6].
- The Procedure:

1. Set coil B through the iron rod and connect to the 6V power supply.
2. Connect the AC voltmeter to the alternative power supply.
3. Connect coil A to the electric bulb.
4. Connect the AC voltmeter with the coil A.
5. Set the DC power supply to on.
6. Put coil A through the iron rod and observe the voltage and bulb.
7. Connect the bulb with coil C and set the power supply voltage to 12V.
8. Set coil C through iron rod and observe the outcome.
9. Record what happens when you remove iron rod. Record the results in Table XVIII.

TABLE XVIII
ELECTROMAGNET

Distance 10^{-2} [m]	6	4	2	No rod
Coil B [V]				
Coil A [V]				
Coil C [V]				

19. Wheatstone Bridge

- Purpose: To understand how to use a Wheatstone bridge.
- Materials: Battery, battery case, wire 100 cm, a scale, ammeter, voltmeter, galvanometer, lead wire, resistor (known), resistor (unknown), resistor (security) [5].
- Procedure:

1. Setting electricity's circuit with the battery to the ammeter, resistor in a series.
2. Connect the resistor (known) and unknown resistor to both ends of the wire.
3. Connect the galvanometer to the contact point of the resistors.
4. Connect the galvanometer to another terminal to determine the balance point of the wire using the lead wire.

5. Read the balance point length comparing the measure attached to the wire.
6. Calculate the resistance using the following equation:

$$X = R \times \frac{BC}{AB}$$

Record the results in Table XIX.

TABLE XIX
WHEATSTONE BRIDGE

AB [m]	
BC [m]	
R [Ω]	
X [Ω]	

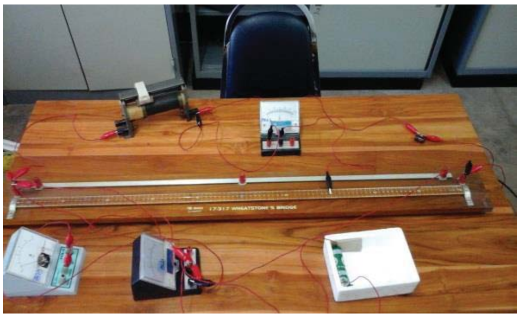

Fig. 1 Wheatstone bridge

In order to conduct this experiment without a Wheatstone bridge, the first step was to build a bridge using iron wire and bamboo rod. Two sets of Wheatstone bridges were later found when moving materials from the storage room.

20. Phase Split Induction Motor

- Purpose: To learn about phase split induction motors.
- Materials: 30V AC power supply, phase split start induction motor (four input lines).
- The Procedure:

1. Connect the blue (sub coil) and black (main coil) wires to the alternative input power line (R). Connect the gray (main coil) and brown (sub coil) wires to the input the alternative power line (S).
2. Observe the rotating direction.
3. Connect the brown (sub coil) and black (main coil) wires to the alternative input power line (R). Connect the gray (main coil) and blue (sub coil) wires with the input alternative power line (S).
4. Observe the rotating direction.
5. Notice the rotation magnet made by stay coils. Record the results in Table XX.

TABLE XX
SINGLE PHASE CAPACITOR INDUCTION MOTOR

	Power line	Power line
Black wire	power line R	
Gray wire	power line S	
Blue wire	power line R	
Brown wire	power line S	
Rotating	clockwise	direction

This anatomy model of an induction motor may have originally been a three-phase induction motor. A section was removed to display the interior structure, and therefore, it is used by a standard single phase in an alternating current.

21. Direct Current Generator

- Purpose: To understand direct and alternate current generators.
- Materials: DC voltmeter, DC ammeter, DC current generator.
- The Procedure:

1. Check the conduction of the rotor made of by the coils.
2. Check the magnet is set to both side of the rotor.
3. Check the conduction between the shaft and brushes.
4. Connect the DC voltmeter to the DC terminal.
5. Turn the rotor and observe the reading on the voltmeter.
6. Connect an AC voltmeter to AC terminal.
7. Turn the rotor and observe the reading on the voltmeter.
8. Switch the AC voltmeter with DC voltmeter and observe the voltmeter reading. Record the results in Table XXI.

TABLE XXI
DIRECT CURRENT GENERATOR

Rotation [Hz]	
DC Voltmeter	
AC Voltmeter	

This is a simple direct current motor made of copper wire and magnets. It was broken at the connection of the coil.

22. Three Phase Alternating Generator

- Purpose: To study a three-phase alternating current generator.
- Materials: DC voltmeter, DC ammeter, three phase alternating current generator.
- The Procedure

1. Check the conduction of each coil.
2. Set the magnet on the rotor.
3. Check the belt between the wheels.
4. Connect DC voltmeter to the DC terminal.
5. Turn the rotor and observe the reading on the voltmeter.
6. Switch the AC voltmeter with the DC voltmeter and observe the reading on the voltmeter. Record the results in Table XXII.

TABLE XXII
THREE PHASE ALTERNATING GENERATOR

Rotation [Hz]	
DC Voltmeter	
AC Voltmeter	

This generator has three coil parts that comprise the electric force by induction. A rotary belt was fixed between the handling pulleys.

23. Electromagnetic Bell

- Purpose: To learn how to use electromagnetic bell.
- Materials: DC voltmeter, DC ammeter, switch, two bells, DC power supply.

- The Procedure:

1. Measure the resistance of the bell.
2. Connect to the power supply, ammeter, switch, and bell in that order.
3. Connect the voltmeter to the bell.
4. Close the switch and observe the readings in the voltage and ammeters.
5. Open the switch and insert one more bell into the circuit in that order.
6. Close the switch and observe the bells and measure each bell reading in the voltmeters and ammeters. Record the results in Table XXIII.

TABLE XXIII
ELECTROMAGNETIC BELL

	Voltage[V]	Current[A]	ringing
Bell 1			
Bell 2			

In order to make bell sound, the distance between the bell chime and the electromagnet should be adjusted such that we can hear the sound clearly.

24. Charging and Discharging Capacitors

- Purpose: To charge and discharge capacitors
- Materials: Oscilloscope, function generator, resistor (6.8k Ω), Capacitor (0.3 μF), probe [8].
- Procedure:

4. Adjust the oscilloscope voltage and time division with the inside signal.
5. Set the function generator rectangular wave frequency 100 Hz.
6. Connect the output of function generator, resistance, and capacitance in serial.
7. Connect the oscilloscope probe CH1 to the function generator, CH2 to the capacitance.
8. Observe the time of saturation of capacitance.
9. Calculate the outline value of the capacitance comparing to the life time of decay of the charge.
10. Change the frequency of the function generator and observe the time dependence of the capacitance voltage. Record the results in Table XXIV.

TABLE XXIV
CHARGING AND DISCHARGING CAPACITORS

Frequency [Hz]	
Time of duration [s]	
Capacitance [F]	

This experiment is a basic experiment. We can make the graph of the voltage between two points of capacitance.

25. Handy Generator

- Purpose: To know how to use handy generators.
- Materials: Handy generator attached to connecting wire, DC voltmeter.
- Procedure:

1. Connect the handy generator to the voltmeter.
2. Rotate the handle and observe the reading on the voltmeter.
3. Connect a second handy generator to it.
4. Rotate one of the generators and observe the other second one.
5. Switch the connecting terminal up and down.
6. Connect with other two generators, and rotate one of them and observe others.
7. Compare the findings from the rotations. Record the results in Table XXV.

A motor can be made from Handy generator. If we connect a second generator, it is possible to observe the transformation from mechanical energy into electric energy, and vice versa.

TABLE XXV
HANDY GENERATOR

Handy generator rotation frequency 1 [Hz]	
Handy generator rotation frequency 2 [Hz]	
Voltage [V]	

26. Current Balance

- Purpose: To study current balance.
- Materials: DC power supply, resistance (100 Ω for safety), DC ammeter, switch, coil, stay, hanging straight line, DC voltmeter.
- Procedure:

1. Measure the length, weight, and shape of the straight line.
2. Measure the coil weight and the shape to determine the number of turns.
3. Change the current and measure the transformation of the line.
4. Determine the relationship between the current and force. Record the results in Table XXVI.

TABLE XXVI
CURRENT BALANCE

Length [m]	
Weight [N]	
Current [A]	
Angle [º]	

This experiment shows the relationship of the force between a magnet and an electric current. This equipment was made in Thailand, and the position of coil and hanging wire was abnormal, and therefore, it was agreed to adjust their position.

27. Standing Waves on a String

- Purpose: To understand the velocity of a traveling wave in a stretched string.
- Materials: String pulling stage weight, nylon thread, steel wire, function generator, audio amplifier, speaker (8 Ω, 5 W), oscilloscope, lead wire [8].
- Procedure:

1. Measure the length and weight, and determine the mass density of the string.
2. Set the string on the frame and hang the weight.
3. Measure the frequency or period of time, and the amplitude of the signals made by the function generator using oscilloscope.
4. Set the output of function generator to the audio amplifier.
5. Set the output of the audio amplifier to the speaker.

6. Place a long paper (paper scroll) between the speaker and the string.
7. Adjust the tension (4:9:1) of the string and measure the wave length.
8. Adjust the density (1:4:9) of the string and measure the wave length.
9. Switch the frequency of the function generator (1:2:3) and measure the wave length.
10. Observe the string resonating from the vibrations from the speaker. Record the results in Table XXVII.

TABLE XXVII
STANDING WAVES ON A STRING

Length [m]	
frequency [Hz]	
Velocity [m/s]	

It is not easy to observe the standing wave of strings, as it requires a low frequency signal amplifier, which was not available.

28. Air Column Resonance

- Purpose: To study air column resonance.
- Material: Test tube stand, measure of air column, the bottom from cut from PET bottles (5.00×10^{-4}m^3), cork, connecting tubes and glass pipe, tuning fork set(C, D, E, F, G, A, B) [7].
- The Procedure:

1. Connect the glass tube with the bottom of the PET bottle using the glass pipes.
2. Tie the thread to the glass tube and holding with stand, hang and hold the PET bottle on the stand pillar.
3. Pour water into the PET bottle and adjust the water levels.
4. Take tuning sound fork C, tap it, and set the glass tube on a good position for sound.
5. Adjust the height of the air column by adjusting the height of the PET bottle by pulling up or down.
6. Measure the level of air inside glass pipe from short to long, three times.
7. Repeat for each of the tuning forks and measure the height of the air column, as above. Record the results in Table XXVIII.

TABLE XXVIII
AIR COLUMN RESONANCE

	10^{-2}[m]	10^{-2}[m]	10^{-2}[m]	wavelength10^{-2}[m]
D [Hz]				
E [Hz]				
F [Hz]				
G [Hz]				
A [Hz]				
B [Hz]				

The necessary equipment to conduct the air column experiment was not available, and the experiment was carried out using glass tubes and PET bottles to make combine pipes.

29. Tuning Forks Beat Frequency

- Purpose: To learn about tuning forks beat frequency.
- Materials: Tuning forks (512 Hz, 514 Hz), wood hammer, resonating boxes, iron wire, aluminum wire [10].
- Procedure:

1. Place the tuning forks (512 Hz and 514 Hz) into the resonance box.
2. Tap both forks simultaneously and count the beat within 10 seconds.
3. Set up a microphone and oscilloscope to record the results.
4. Observe the wave of sound and measure the period of a beat.
5. Place a length of wire on the 512 Hz tuning fork, tap and count the beats for a period of 10 seconds and record the reading on the oscilloscope. Record the results in Table XXIX.

TABLE XXIX
TUNING FORK BEAT FREQUENCY

512 Hz	1st	2nd	3rd	Beat Hz
514 Hz				
Hz				

Tuning forks are used by musicians, and the used in the experiment consisted of a full set of musical tone levels. There are five sets available.

30. Specific Heat of Metals

- Purpose: To understand heat energy conservation and specific heat
- Materials: Water heat reservoir, metal weight (Cu, Fe, Al, and Pb), length of cotton thread, thermometer, mesh cylinder, beaker, plastic beaker, boiling heater [2].
- Procedure:

1. Record the temperature of the water held at ambient temperature water using the mesh cylinder.
2. Pour the water 1.00×10^{-4} m^3 into the reservoir.
3. Record the temperature t_2 of the water.
4. Pour the hot water into the plastic beaker.
5. Put the metal weight into the hot water.
6. Record the hot water temperature t_1 with the metal weight.
7. Remove the metal and place in the water in the reservoir.
8. Stir the water until temperature of the metal becomes equal to the temperature of the water and measure the temperature t of the reservoir.
9. Determine the specific heat. Record the results in Table XXX.

TABLE XXX
SPECIFIC HEAT OF METALS

	m_1 10^{-3}[kg]	m_2 10^{-3}[kg]	t_1 [º]	t_2 [º]	T [º]	t_1-t [º]	t-t_2 [º]	C_1 [J/kg.K]	C_1 known [J/kg.K]
Cu									
Fe									
Al									
Pb									

This heat reservoir is a well-known material. Attention needs to be focused on the heat ratio activity, and thus, the last balanced temperature should be nearest to room temperature.

31. Boyle's Law

- Purpose: To understand Boyle's law, relation between pressure and volume of a gas
- Materials: syringe, rubber cork, weight balance, Adhesive tape, weights (0.100 kg, 0.200 kg, 0.500 kg, 1.000 kg).
- Procedure:

1. Insert a rubber cork on the injector nozzle of the syringe.
2. Set the syringe horizontally and inhale the air 20×10^{-6} $[m^3]$ in the syringe.
3. Close the syringe nozzle with adhesive tape.
4. Put the syringe on the balance with piston side.
5. Adding the weight and read the volume of the syringe.
6. Fill out the table and draw the relation between pressure and volume of the gas. Record the results in Table XXXI.

TABLE XXXI
BOYLE'S LAW

Weight10^{-3}[kg]	0	80	180	280	380	480	580
ΔP $[N/m^2]$							
V 10^{-6} [m^3]	20.0	19.6	19.1	18.8	17.7	16.7	15.8
ΔV 10^{-6} [m^3]							

It was the weak point of this experiments that air leaks for big weight pressure. We do not have the corks that have no hole.

32. Diffraction of a Laser Beam

- Purpose: To observe the wave feature of light.
- Materials: Laser beam projector, grating $(1.00\times 10^5\ line/m$, $3.00\times 10^5\ line/m,$ $5.00\times 10^5\ line/m)$, ruler (1.00 m) [14].
- Procedure:

1. Set up the laser beam projector.
2. Set the grating.
3. Measure the length L between the grating and the wall.
4. Turn on the projector.
5. Measure length X between the laser points. Record the results in Table XXXII.

TABLE XXXII
DIFFRACTION OF A LASER BEAM L= (1.00) M

	0	1st spot	2nd spot	3rd spot
$1.00\times10^5[line/m]$				
$3.00\times10^5[line/m]$				
$5.00\times10^5[line/m]$				

Grating is plastic film, so it is simple to make the gratings. Diffraction of the laser beam occurs on the wall, and we can see clear interference spots in the case of the laser beam [2].

The equipment was controlled and tested while developing the experiments included in the textbook. The rest of the equipment is the light sources glass tubes of H_2, Ne, Ar [13]. Unfortunately, the authors cannot observe the spectrum of these atoms, because the spectroscope does not work. And the photodetector was also not working because of defaults. A total of 32 experiments were developed to utilize the available equipment. The teachers thought that they could not perform the experiments with the students in classroom at the last time [1]. But right now, they confirm the possibility to perform of experiments.

III. PRACTICE

A. Teaching Plan

We have devised over 32 experiments. The experiment class plan was determined over two semesters for a total of 32 weeks. The first 16 weeks will focus on the mechanics and basic electricity experiments, while the second 16 weeks will look at the electromagnetics, and the heat and wave fields. The schedule is shown in Table XXXIII below.

TABLE XXXIII
TEACHING SCHEDULE PLAN

	Text1	Text2	Text3	Text4	Text5	Text6
Week1	Group1	Group2	Group3	Group4	Group5	
Week2		Group1	Group2	Group3	Group4	Group5
Week3	Group5		Group1	Group2	Group3	Group4
Week4	Group4	Group5		Group1	Group2	Group3
Week5	Group3	Group4	Group5		Group1	Group2
Week6	Group2	Group3	Group4	Group5		Group1

The students are able to access the textbooks through the e-Learning system. The students were expected to prepare before class and conduct experiments in class, and then prepare a presentation of the results. The presentation consists of PowerPoint slides, and contains the results of the experiment and supporting material including pictures and video recordings of the conducted experiments. The students have a week to write up their presentations which they present to the class for discussion.

The students record the report of their presentation for assessment. The teachers grade the presentation and the report. The experiment files submitted by students will then be made available by the teacher on the resource website.

B. Class Practice

We gave the student ID card and name list to the administrator of e-Learning system. We thought that when they typed their ID name and password from ID card number, they could log-in the site. But, they could not log-in the e-Learning site. We could not understand the process of accessing the site. It was a problem, and students and teachers have to prepare to access the internet by themselves.

At last, students logged in as a guest. They could get the textbook from the site. We explained about the class. What and how do we do in this experiment class? Students have to download the textbook files every week. Students prepare and perform experiment with each group members. After performing the experiment, they have to present their experiment. But second time, they took and made their materials from the experiment room for themselves and performed their experiments. They took pictures or movies and were making slides for presentation.

For the third time, they presented their experiment using PowerPoint slides and video clips in the class room. One group did not complete the presentation; they used a number of programs for the data collection and analysis including Microsoft Word, Excel, MATLAB, and Scilab programs.

We advised about the treat for numerical values for measurements because some groups showed long decimal numbers or the order of the numbers.

Fig. 2 Presentation of class experiments

As for the class hour, this was not sufficient time, and in fact, 4.5 hours were needed to complete one unit of the experiments in class. Therefore, smaller experiment classes should be considered in order to reduce the time needed to complete the exercises. Students attending the experiment classes are required to follow the textbook, prepare and perform experiments, present reports, and submit the requested files, and then, weekly time schedules of experiments can be used for the teaching plans [15].

As the small group is better, we can use this group size.

As for presentation, some groups put many sentences on one slide. So, we will advise again when they will present about their reports.

As for reports, many group submitted them in CD. We told students submit via CD or upload on the e-Learning site.

IV. Conclusion

The students attending NUOL are keen to learn and regularly attended the prepared lectures and classes. They were also active in the classroom, asking questions to the lecturer and joining in class discussions. When we perform the experiment classes, through experiment, through presentation, we found that they understand better. They thought and improve their experiments and explanation. However, the students still faced a number of difficulties including downloading the experiment textbook from the Internet. This was due mainly to the limited Internet accessibility which impedes their ability to learn.

The materials available to conduct the experiments were also very limited. Some students struggled to set up the experiments and required additional assistance. Some students also had difficulties in reading the parameter values.

In addition to our revision of the student experiment materials, students were also asked to devise their own experiments. The students were able to formulate simple and easy-to-understand experiments in which they utilized materials that they had gather from various places. Although it was felt that adequate teaching could not be provided because of the shortcomings associated with the lack of materials, equipment, and facilities, the students maintained their enthusiasm and commitment to learning. The authors of this study are proud of the efforts of the students. The Faculty of Education at NUOL does not have sufficient budget for a modern well-equipped laboratory; however, a way was found to make the best possible use of the available space and equipment.

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