PRACTICUM GUIDE

BASIC PHYSICS I

BASIC PHYSICS LECTURER TEAM

DEPARTMENT OF PHYSICS
FMIPA UNIVERSITAS NEGERI JAKARTA
2022

FOREWORD

Praise be to Allah SWT. This gratitude is accompanied by the completion of the improvement of the Basic Physics I practicum manual which has not been revised since 2006.

This practicum guidebook basically refers to the syllabus of the Basic Physics I course for the chapters of Wave-Optics and Electric-Magnetic. However, this guidebook is far from perfect.

In general, this book is divided into two main parts: the chapter on optics which consists of modules: refractive index, mirrors, lens properties and shadow defects, microscope, spectrometer, polarimeter, and oscilloscope. While the next chapter is electricity which consists of 3 modules: alternating current, incandescent lamp characters, and transformers. In addition, this practicum guidebook is also equipped with a discussion of statistical methods indata processing. It is intended that students understand how to conduct a more comprehensive analysis of the practicum data by calculating the uncertainty factor in the measurement. Significant figures are also presented so that students understand how to write quantitative results from the practicum that has been done.

In writing this Basic Physics I practicum guidebook, we would like to t h a n k all those who helped make improvements. Our gratitude is especially addressed to the Head of the Physics Department, Prof. Dr. Agus Setyo Budi, and to Dr. Esmar Budi, Hadi Nasbey, M.Si, Iwan Sugihartono, M.Si, as well as the entire Basic Physics lecturer team in the academic community of the Physics Department FMIPA State University Jakarta. We would also liketo thank Sifa Alfiyah and Syafrima Wahyu as teaching assistants who helped in the writing process of improving this practicum guidebook.

Finally, we hope that this Basic Physics I practicum guidebook can be useful for all students who are taking Basic Physics I Practicum courses.

Jakarta, September 2022

Physics Lecturer
Team.

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RULES OF CONDUCT

1. Prerequisite for practicum
    a. Wear the designated laboratory coat
    b. Wear neat clothes (collared shirt/shirt, long pants/skirt) and shoes.
    c. Wear identification
    d. Brought a neatly bound preliminary report
    e. Prepare yourself with the material that will be practiced
    f. Pass the preliminary test (if applicable)
2. Attendance
    a. Practitioners must be present 15 minutes before the practicum starts
    b. Practitioners who are late are declared to have failed the practicum
    c. Practitioners who are absent from practicum due to illness are required to show an official certificate from a doctor.
3. Practicum Implementation
    a. In the laboratory, practitioners must be calm, orderly, polite, neatly dressed, and wear a laboratory coat. Bags, hats, and other items not related to the practicum are stored in the lockers.
    b. Practitioners must understand what will be practiced
    c. Practitioners must obtain data in accordance with what is practiced
    d. Practitioners must prepare equipment (assisted by assistants) and tidy up the equipment that has been used as before.
    e. Practitioners must maintain order, safety, and equipment used.
    f. Practitioners are strictly prohibited from smoking, bringing food and drinks, disturbing other groups, and leaving the laboratory without the permission of the assistant or person in charge of the practicum.
    g. After the practicum is completed, practitioners are required:
        i. Ask for the signature of the person in charge of the practicum or assistant on the observation data paper
        ii. Asked for the graded preliminary report back
        iii. Ask the assistant for the final project
4. Assessment
    a. Practicum grades are determined from : Preliminary test (if any), preliminary report, activity during practicum (work value), final practicum report, and presentation of practicum results (if any).
    b. Practicum graduation is determined based on the average practicum score and attendance (100% mandatory practicum participation).
5. Sanctions
    a. Practitioners who follow the follow-up practicum are carried out in the first week starting after the entire practicum is completed.
    b. Practitioners who do not follow the practicum 3 times and do not follow the follow-up are declared not to pass
    c. Practitioners are required to replace damaged or lost equipment during the practicum with the same equipment or a fine of Rp. 250,000 before participating in the practicum the following week.

STATISTICAL METHODS IN DATA PROCESSING

Least Square Method

The least squares method is a method that is widely used to see the linear trend of an observation data. Suppose we have a number of observation data, namely:

$$x \longrightarrow x_1, x_2, x_3, \ldots, x_n \qquad (1)$$

$$y \longrightarrow y_1, y_2, y_3, \ldots, y_n$$

The linear relationship between the data y_1 and x_1 is

$$y = a + bx \quad (2)$$

the value of the coefficients a and b by the least

squares method:

$$a = \frac{\sum y \sum x^2 - \sum x \sum xy}{n\sum x^2 - \left(\sum x\right)^2} \qquad (3)$$

$$b = \frac{n\sum xy - \sum x \sum y}{n\sum x^2 - \left(\sum x\right)^2} \qquad (4)$$

$$S_a = S_y = \sqrt{\frac{\sum x^2}{n\sum x^2 - \left(\sum x\right)^2}} \qquad (5)$$

$$S_b = S_y = \sqrt{\frac{n}{n\sum x^2 - \left(\sum x\right)^2}} \qquad (6)$$

$$S_y^2 = \left(\frac{1}{n-2}\right)\left[\sum y_i^2 - \frac{\sum x_i^2\left(\sum y_i\right)^2 - 2\sum x_i \sum x_i y_i \sum y_i + n\left(\sum x_i y_i\right)^2}{n\sum x^2 - \left(\sum x\right)^2}\right] \qquad (7)$$

The correlation coefficient r expresses the strength of the relationship between data y_i and x_i is

$$r(x,y)=\frac{S_{xy}}{S_x S_y}=\frac{\sum((x_i-\bar{x})(y_i-\bar{y}))}{\sqrt{\sum(x_i-\bar{x})^2\sum(y_i-\bar{y})^2}} \quad (8)$$

$$r(x,y)=\frac{n\sum x_i y_i-\sum x_i \sum y_i}{\sqrt{\left[n\sum x_i^2-\left(\sum x_i\right)^2\right]\left[n\sum y_i^2-\left(\sum y_i\right)^2\right]}} \quad (9)$$

Normal Distribution

The Gauss distribution is used for repeated observation data.Steps:

1) Arrange the data from the smallest, i.e. A, to the largest, i.e. Z. Then determine Z - A.
2) Determine the number of classes K, select the numbers: 3, 5, 7, 9, … for the number of data more than 40, if doubtful, use the equation

$$K = 3.3\log N + 1 \quad (10)$$

(N=Number of data)

3) Calculate the class interval = $\frac{Z-A}{K}$
4) Arrange table interval class by determining the frequency f (number of data which fulfill the class). Use the first class smaller than A and the last class larger than Z. For example A = 0.0803, Z = 0.1278 and K = 19 and than value of $\frac{Z-A}{K}$= 0.0025.

Class	f_i
0.0800 - 0.0825	....
0.0826 - 0.0850	....
...	
...	
...	
...	
...	
0.1256 - 0.1281	....

5) If the shape of the short graph is symmetrical, determine the middle data, e.g. 0.0800-0.0825 and calculate it with x_i

6) For large or very small values of x_i, the solution can be simplified by drawing the price of x_i is just an integer from 0, 1, 2, 3, ...etc.

7) The table is as follows:

Table 1.Table for Gauss distribution

No.	x_i	f_i	x_i	$x_i - \bar{x}$	$f_i (x_i - \bar{x})$	$f_i (x_i - \bar{x})^2$
1			0			
2			1			
3	$x*$	$f >$	$2 = \bar{x}$			
4			3			
...						
...						
		$\sum f_i$			$\sum f_i (x_i - \bar{x})$	$\sum f_i (x_i - \bar{x})^2$

The value of x^* is the price of x_i with the largest frequency

8) Calculate Coefficient of Fraction and Standard Deviation

$$F = x^* + \left[\frac{\sum i f_i (x_i - \bar{x})}{N} \frac{Z - A}{K}\right] \tag{11}$$

$$S = \left[\frac{\sum i f_i (x_i - \bar{x})^2 - \left(\sum i f_i (x_i - \bar{x})\right)^2}{N(N-1)}\right]^{1/2} \frac{Z - A}{K} \tag{12}$$

End result X = F ± S

Note

S > 0 only if the graphical distribution is normal or symmetrical. If not symmetric, select data, discard data, data that is expected to create a large deviation. Intervals until they are symmetrical.

Significant figures (AP)

Consider the results of measuring the thickness of the thick powder as follows: x_1 = (12.1±0.5) mm and x_2 = (12.0 ± 0.06) mm. The first means that the correct thickness is within the range of 11.6 mm - 12.6 mm, while the second means that the correct thickness is within the range of 11.94 - 12.06 mm.

The first measurement of thickness, is expressed in three significant*figures,* while the second measurement is expressed in four significant figures. *The more precise the measurement, the more numbers can be included in the report.* This becomes clearer by deepening the understanding of the accuracy of the measurement.

The statementx = x ± Δx, states the absolute ktp of the quantity x and describes the quality of the measuring instrument used. While Δx/x by multiplying by 100%, states the relative measurement accuracy (ktp) associated with measurement accuracy. The smaller the relative ktp, the more precise the measurement.

From the above example Δx/x = (0.5/12.1)x100% = 4.1% for the first thickness, and Δx/x = (0.06/12.06)x100% = 0.5% for the second thickness. It is said that the second thickness measurement has an accuracy of approximately 10x that of the first thickness measurement.

PRACTICAL RULES

MEASUREMENT ACCURACY (KTP RELATIVE)	**NUMBER OF APS USED**
≅10%	2
≅1 %	3
≅ 0,1%	4

Example

x = 1202 ± 10% means (1202 ±120.2). With 2 AP the result of this measurement should be written= $(1.2\pm 0.1) \times 10^3$

x = 1202 ± 1% means (1202 ± 12.02). With 3 AP the result of this measurement should be written $x = (1.20 \pm 0.01) \times 10^3$.

x = 1202 ± 0.1% means (1202 ± 1.202). With 4 AP the result of this measurement should be written $x = (1.202 \pm 0.001) \times 10^3$

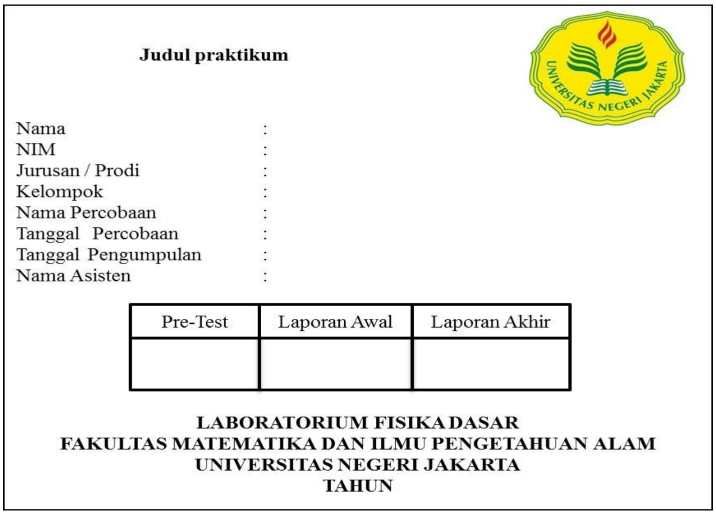
FINAL REPORT FORMAT

Report writing

1. The report is written on A4 size HVS paper and may be reversed.
2. Written in neat handwriting or typed on a typewriter (manual or electric)
3. Graphing the results of data processing is done on millimeter block paper with a precise scale.

Format of preliminary report

1. Home page



Judul praktikum

Nama :
NIM :
Jurusan / Prodi :
Kelompok :
Nama Percobaan :
Tanggal Percobaan :
Tanggal Pengumpulan :
Nama Asisten :

Pre-Test	Laporan Awal	Laporan Akhir

LABORATORIUM FISIKA DASAR
FAKULTAS MATEMATIKA DAN ILMU PENGETAHUAN ALAM
UNIVERSITAS NEGERI JAKARTA
TAHUN

2. Next page:
   a. Destination
   b. Tools and materials
   c. Theory
   d. How it works

Final report format

The final report is prepared based on the preliminary report that has been made, as for the structure is:

1. Preliminary report that has been assessed by the assistant
2. Experimental data
3. Data processing
4. Analysis and discussion
5. Conclusions and suggestions
6. Bibliography

P1: ROD ELASTICITY

A. PURPOSE

1. Understand the elastic properties of materials under flexing.
2. understand the relationship between flexure and load.
3. Can determine Young's Modulus from flexing.

B. TOOLS AND MATERIALS

1. Stems to be researched
2. Support device,
3. Reading device
4. Load device
5. Load
6. Mistar
7. Scope
8. Screw micrometer.

C. BASIC THEORY

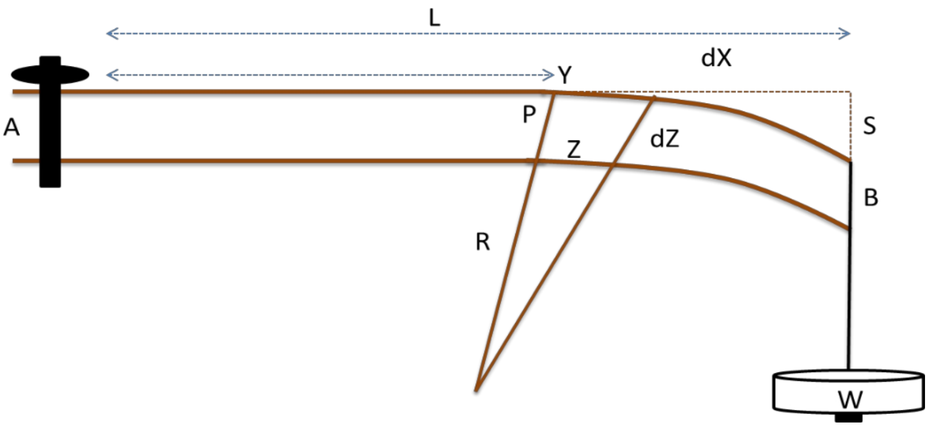


Figure 1: A Metal Bar Under Load

Figure 1 shows a metal rod that is clamped at one end, and the other end B is a p p l i e d a force W. The elements above the midline (neutral axis) are stretched, while those below the line are compressed By ignoring the weight of the rod to the right of P, the moment of flexure(MP) at P can be calculated as:

$$MP = W(L - x) \tag{1}$$

If the curvature of the rod at P is 1/R, we consider a filament of length dx at P, with thickness dz and distance from the normal axis z. Let's call the width of the rod at that point b. Using two congruent triangles, we get :

$$\frac{growth \quad long \quad dx}{z} = \frac{dx}{R} \qquad (2)$$

So,

$$Strain\ in\ the\ filament = \frac{growth \quad long \quad dx}{dx} = \frac{z}{R} \qquad (3)$$

Since Stess = Strain x E; where E is Young's Modulus, then

$$Stress = \frac{Ez}{R} \qquad (4)$$

So the voltage inside the filament is:

Stress x cross-sectionalarea = $\frac{Eb}{R} z^2 dz$ (5)

Thus, the total moment of force at P, is:

$P = \frac{E}{R} \int bz^2 dx = \frac{E}{R} I$ (where $I = \int bz^2 dz$ = moment of inertia cross section the rod about the neutral axis. This quantity is also referred to as the external moment W(L-x). For very small flexures,

$\frac{1}{R} = \frac{d^2y}{dx^2}$, Because $\frac{1}{R} = \frac{d^2y/dx^2}{\{1+(\frac{dy}{dx})^2}$ and $\frac{dy}{dx}$ very small. (6)

So,

$$EI\ \frac{dy}{dx^2} = W(L-x) \qquad (7)$$

Integrated $EI\ \frac{dy}{dx} = WLx - \frac{Wx^2}{2}$ (8)

Konstanta integrasi = 0, karena $\frac{dy}{dx}$ = 0 at x = 0

Integrated again $EIy = \frac{Wlx^2}{2} - \frac{Wx^3}{6}$ (9)

Constant of integration = 0, because y = 0 at x = 0.

At point B, where x = L, y = S, in other words

$$EIS = \frac{WL^3}{3}\ or\ E = \frac{WL^3}{3IS} \qquad (10)$$

Since the rod is supported by two blades and loaded in the middle, the force W acting on the half rod is Mg/2, and since E = MgL^3 /48IS. For a rectangular rod cross

section I = $bd^3/12$, and the graph above M/s = OB/AB,
Then,

$$E = \frac{L^3 g}{4bd^3} \cdot \frac{OB}{AB} \qquad (11)$$

D. HOW IT WORKS

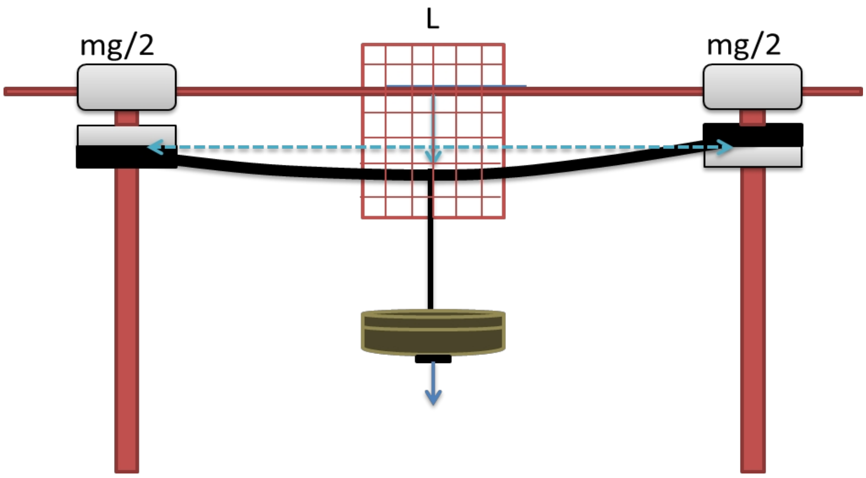


Illustration of Rod Elasticity

1. Measure the width and thickness of the rod at several different places for 10 measurements (measurement using a caliper and a screw micrometer).
2. Measure the distance between the two support bars.
3. Place the rods on top of the supports at an even distance.
4. Place the load device at the center point of the rod and mount the reading device on the table (see figure).
5. Read device designation when the load device is empty.
6. Install the weights successively with the available weights. At the time of adding one piece of load, wait for a while and then record the drop in the center point of the rod on the reading device.

7. After all available weights have been used, reduce them successively. After each reduction of one piece of load, wait for a while and then read the increase in the center point of the bar on the reading device.
8. Repeat the experiment by changing the distance between the support bars
9. The reading of the center point position of the rod was taken five times.
10. Repeating the distance between the support blades for 3 changes.

E. CONSIDERATIONS

1. Draw a graph between the decrease/increase of the center point of the rod and the mass of the load.
2. From the graph, determine the slope of the straight section.
3. Determine Young's Modulus complete with relative error

F. QUESTION

1. Determine the maximum load that should be hung on the end of a steel with a diameter of 1.0 mm. If its strain must not exceed 0.001 of its initial length, and the young's modulus for steel is 2.0xl0^{-11} Nm^{-2}
2. A 2.0 m long steel plate is placed flat, and supported at both ends while its midpoint is loaded with a mass of 1 kg. What is the drop in the center point? It is known that the Young's modulus of steel is 2.0 x 10^{-11} Nm^{-2}, the thickness of the plate is 0.5 cm while the width is 8 cm, g = 10 ms^{-2}

P2: SIMPLE HARIMONIC MOTION (GHS)

A. PURPOSE

1. Understand the behavior of objects that perform simple harmonic motion and the quantities associated with simple harmonic motion.
2. Understand the conditions needed for an object to experience simple harmonic motion.
3. Measure the period (vibrating time) of a loaded spring undergoing simple harmonic motion.
4. Determine the force constant of a loaded spring undergoing simple harmonic motion.

B. TOOLS AND MATERIALS

1. Spring and statip (for hanging the spring).
2. Buckets and load pieces.
3. Stopwatch.
4. Technical balance and weights.

C. BASIC THEORY

According to Hooke's Law, a force is required to change the shape of an object, provided that the elasticity limit of the object has not been exceeded. If only limited by the pushing and pulling forces, what happens is not a change in shape, but a change in position, which is a displacement from the point where the force acts to another point. The relationship between force F and displacement x from an equilibrium position is expressed as follows.

$$F = -k.\ x \quad (1)$$

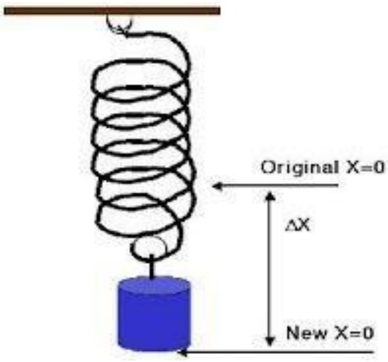
where k is the force constant.

If we pull or press a spring with our hands so that it changes its length by x from its free state, this requires a force of F = k.x As a reaction, the spring exerts pressure or pull on our hands and this reaction force can be expressed as :

$$F' = -k.\ x \qquad (2)$$

The force F' is called the elastic restoring force. The minus sign indicates that the restoring force is always opposite to the direction of displacement x, which means that the direction of the restoring force is always towards the equilibrium of the object.

If a loaded spring that is initially in an equilibrium state (Fig.1) then the load is pulled down with a deviation of A from its equilibrium position (x = 0) and released, the load will move back and forth up and down around its equilibrium position with a maximum deviation A.



A tensile force on a spring, which causes a change in the length of the spring

If frictional forces can be ignored, so that in its periodic reciprocating motion no energy is lost, then this motion will be able to continue.

This kind of motion is called simple harmonic motion (ghs). The cause of this ghs is the operation of an elastic restoring force F = - k.x on the object. If Newton's second law F = m.a is applied to this motion, with F = - k.x; where $a = d\, x/dt^{22}$, the equation will be obtained:

$$k.x = m.d\, x/dt^{22} \text{ , or}$$

$$dx/dt^{22} = -\, k.x/m \qquad (3)$$

This equation is called the equation of motion of the ghs. How do we solve the above equation? By solving equation 3 using differential equations, we get the relationship of distance or deviation to time as follows:

$$X = A\, \mathrm{Cos}(\omega t+\theta) \qquad (4)$$

with ;

$\overline{\omega} = \sqrt{\frac{k}{m}}$ is called angular frequency

A = Amplitude or maximum deviation
(ω+θ) = phase of the ghs

Θ = phase constant

If t in (4) increases by $\frac{2\pi}{\omega}$, then

$$x = A.\cos\left\{\overline{\omega}\left(t + \frac{2\pi}{\overline{\omega}}\right) + \theta\right\}$$

$$x = A.\cos\{\overline{\omega}t + 2\pi + \theta\}$$

$$x = A.\cos\left\{\overline{\omega}\left(t + \frac{2\pi}{\overline{\omega}}\right) + \theta\right\}$$

Since after 2π/ω the function repeats itself, this means that the period T of ghs is equal to 2π/ω, so;

$$T = \frac{2\pi}{\overline{\omega}} = 2\pi\sqrt{m/k} \qquad (5)$$

From equation (5), if T and M are known, the force constant k can be determined.

D. HOW IT WORKS

1. Weigh the spring, weight bucket using a technical balance to determine the mass of each.
2. Hang the spring on the stative and hang the weight bucket on the lower end of the spring. Pull the bucket until a small deviation is obtained and release it, the system will perform ghs. (If it turns out that the vibration period is too small add some weight to the bucket and consider the mass of the weight piece and the bucket as the mass of the "empty bucket").
3. Record the swing time with a stop watch in 5 vibrations (remember!... the calculation of vibrations and time is done when the spring movement is harmonious).
4. Add a load chip and repeat experiments d.2 and d.3.
5. Repeat experiment d.4 by reducing the load one by one.

E. CONSIDERATIONS

1. Determine the spring force constant in this experiment through the formula;

$$T = 2\pi\sqrt{\frac{m}{k}}$$

with T = swing period, m = total mass of the system undergoing ghs, in this experiment m =M +$M_{bebanember}$

2. Draw a graph between T^2 and M_{beban} . What is the shape of the graph?
3. From graph E-2 also determine the price of k! How did you do it?
4. Discuss possible sources of error in this experiment.

F. QUESTION

1. Show that the total energy of an object undergoing ghs

$$Etotal = \frac{1}{2}\, k.A^2 \text{ vibration } amplitude$$

2. What is the ratio of kinetic energy and potential energy of an object undergoing ghs when its deviation is equal to half its amplitude.
3. An object with a mass of 10 grams undergoes a ghs with an amplitude of 24 cm and a period of 10 seconds. At time t=0 the deviation of the object is +24 cm.
   a. What is the deviation of the object at time t = 0.5 seconds?
   b. What is the magnitude and direction of the force on the object when t = 0.5 seconds?
   c. What is the minimum time required for the object to move from its initial position to the point where its deviation is equal to - 12 cm.
   d. What is the velocity of the object when the deviation is - 12 cm.
4. Show that equation (4) is the answer to the equation of motion (3) if;

$$\varpi = \sqrt{k/m}$$

5. From equation (4) derive the velocity v and acceleration of ghs (simple harmonic motion)!
6. Show that the velocity of an object undergoing ghs can be expressed as;

$$v = \pm\sqrt{k/m\,(A^2 - x^2)}$$

7. Show that the projection on the midline of a body doing circular motion at a fixed rate is ghs (simple harmonic motion)!
8. The swing motion of a mathematical pendulum with a small enough angular deviation

is ghs. Derive the formula for the period of a mathematical pendulum.

P3: MATHEMATICAL SWING

A. PURPOSE

To determine the local acceleration of gravity.

B. TOOLS AND MATERIALS

1. Stopwatch
2. Metal balls (± 2 pieces).
3. Rope (thread)
4. Long ruler.
5. Stative

C. BASIC THEORY

Mathematical swing (simple swing) consists of a pendulum *m* suspended from a light string.If the pendulum m is given a slight deviation to the left or right from its balanced position and then released, the pendulum *m* will move back and forth around its balance point, if there is no twisting in this movement, this movement is called simple harmonic motion, see Figure 1.

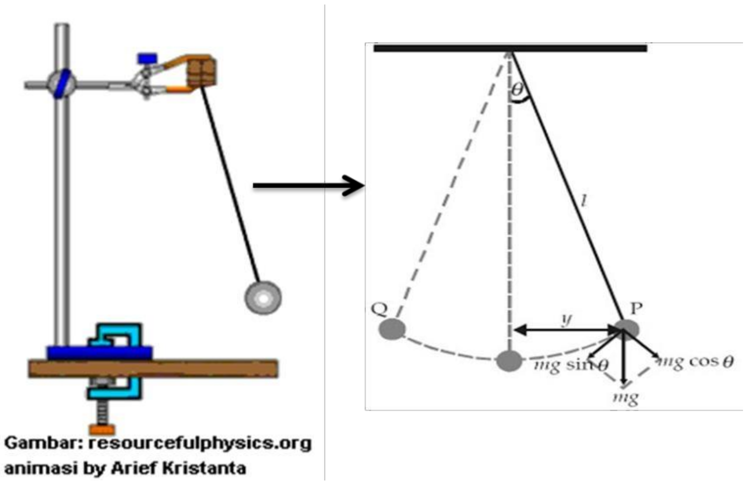


Figure 1. Simple swing

In a simple swing with a rope length l, the line traveled by the pendulum is not a straight line but an arc of a circle with radius l, or

$$x = \theta \,.\, l \qquad (1)$$

x = Distance traveled

θ = angle of deviation of the pendulum

l = length of swing rope

In a simple swing, a reversing force that fulfills Hooke's Law works in order for simple harmonic motion to occur, where the magnitude of the force is :

$$F = -k.\ x \quad (2)$$

In figure (1) we see that there are two forces acting on *m*, namely the weight of the pendulum mg and the rope tension T. The force component mg Cos θ is proportional to T and the force component mg Sin θ is the force that always tries to return the pendulum to its balanced position, so we can write :

$$F = -mg \sin \theta \quad (3)$$

For small θ ($\pm 0^0$ - 15^0), then Sin θ = θ. So equation (3) can be written as :

$$F = -\ mg\ \theta \qquad (4)$$

From equations 2 and 4 we get

$$k = \frac{mg}{l} \qquad (5)$$

For simple harmonic motion the period of vibration is:

$$T = 2\pi \sqrt{\frac{m}{k}} \qquad (6)$$

from equations (5) and (6) we get

$$T = 2\pi \sqrt{\frac{l}{g}} \qquad (7)$$

A simple swing is a simple method that is accurate enough to measure the acceleration of the earth's gravity in a place, by observing the following conditions:

a. The hanging rope is not elastic.

b. The pendulum is small enough and its shape is such that the effect of friction with air is negligible
c. The given deviation (θ) is quite small, this can be overcome among other things by using a long enough rope.

By adjusting and measuring T we can calculate the acceleration of gravity in a place. For better measurements, make measurements with different lengths t and different pendulum masses m.

D. HOW IT WORKS

1. Hang a metal ball with a string (yarn) on a stative as shown in figure(l). In a simple pendulum, the mass is centered at the end of the string, while the mass of the string can be ignored.
2. Measure the length of the hanging rope measured from the knot point on the stative pole to the center of the ball. Take the length of the rope $\geq$ 1 meter.
3. Give a small deviation as described above (maximum limit of θ) is then released and attempts are made to avoid torsional movement.
4. Let the pendulum swing for 30 seconds. Then record the time it takes for the pendulum to make 50 vibrations. Record the time for every 10 vibrations, taking 5 measurements.
5. Repeat step 2 to step 3 for different lengths of rope (10 different lengths of rope). Measure the time for 50 vibrations, taking 1 measurement.
6. Repeat steps 2 and 3 for different pendulum weights and take measurements as in step 5.

E. CONSIDERATIONS

1. Calculate the value of g using the data you have obtained from the experiment.
2. Draw a graph of the relationship T^2 against l, then determine the coefficient of the direction of the straight line that occurs, then determine the price of g from the graph, then compare it with the results of the calculations that you can (explain).

F. QUESTION

1. Prove that $T = 2\pi \sqrt{l/g}$
2. If the gravitational acceleration on a planet is 5g, where g is the earth's gravitational acceleration and a simple pendulum on earth has a swing time T, what is the swing time of the pendulum if it is brought to the planet.
3. Write down the general period of vibration for maximum deviation = θ
4. Why the deviation formed should not be large.

P4: COEFFICIENT OF VISCOSITY OF LIQUID

A. T U J U A N

1. Understand that objects moving in a fluid (liquid or gas) will get friction caused by the viscosity of the fluid.
2. Determine the coefficients of viscosity of a liquid, in this case glycerin, by measuring the fall time of balls in the fluid.

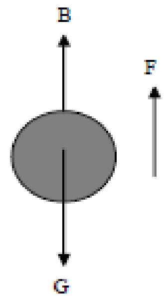
B. TOOLS AND MATERIALS

1. Tube containing liquid
2. Small balls of solid substance
3. Screw micrometer, ruler caliper
4. Thermometer
5. Strainer spoon to pick up the ball from the bottom of the tube
6. Two wire bracelets wrapped around a tube
7. Stop-watch
8. Areometer
9. Scales torque with the weighing stone.

C. BASIC T E O R I

If an object is dropped into a liquid with no initial velocity, it will accelerate due to the force acting on it. The force acting on the object can be described as follows:

$$\sum F_y = \text{G-B-F} = \text{m.a}$$



With
G = weight of the
object B = upward
buoyancy force
F = friction force

The force experienced by the object is directly proportional to the speed, this kind of force is called Newtonian friction force and liquid. In this case, the fluid used is called Newtonian fluid. If the object is spherical, according to Stokes, the force experienced by the object canbe formulated as follows:

$$F = 6\prod r\eta v \qquad (1)$$

where,

F = friction force acting on the ball

η = viscosity coefficient of the

fluid r = radius of the sphere

v = the velocity of the fluid

The use of Stokes' law requires several conditions, including:

a. The space where the fluid is infinite is quite large/wide compared to the size of the object.
b. There is no turbulence in the fluid.
c. The velocity v is not large, so the flow is still laminar.

If a solid sphere with mass density ρ is released on the surface of a liquid with no initial velocity, the sphere will initially accelerate. As the velocity of the ball increases, so does the Stokes force acting on the ball. Eventually the ball will move at a steady speed. This steady motion occurs after a balance is reached between the weight, buoyancy (Archimedes) and Stokes forces on the ball.

If the speed increases, the friction force will also increase, so that one day there will be a dynamic equilibrium, where the object moves without acceleration. The friction force is formulated:

By entering the prices of these forces, it can be obtained

$$\eta = \frac{2}{9} r^2 (\rho_{bola} - \rho_{cairan}) {}^{g}/_{v} \quad (2)$$

From equation (2), the equation can be derived:

$$Tr^2 = \frac{9\eta d}{2g} (\rho_{bola} - \rho_{cairan}) \quad (3)$$

T = the timeit takes for the ball to travel

d = the distance of the falls

Correction: In the experiment conducted, condition (a) was not fulfilled, because the fluid to be determined for the viscosity coefficient was placed in a tube of finite size, so that the radius of the ball could not be neglected with respect to the radius of the tube. In such cases the velocity of the ball must be corrected by:

$$v_0 = v(1 + \frac{kr}{R}) \quad (4)$$

Because: v = d/t equation (6-4) can be written as:

$$\frac{T}{T_0} = \frac{kr}{R} + 1$$

D. HOW IT WORKS

1. Measure the diameter of each ball with a screw micrometer. Take 5 measurements for each ball.
2. Weigh each ball with a torsion balance.
3. Measure the inner diameter of the tube, 5 times.
4. Record the temperature of the liquid before and after the experiment
5. Measure the mass density of the liquid before and after each experiment with an Areometer.
6. Place the wire bracelet that coils the tube approximately 5 cm below the surface of the liquid and the other approximately 5 cm from the bottom of the tube.
7. Measure the drop distance d (Distance between the two wire bracelets).
8. Insert the filter spoon to the bottom of the tube and wait until the liquid is still.
9. Measure the fall time T for each ball for 5 repetitions each.
10. Change the location of the wires so that the distance d changes as well. Measure d and T as in steps 7 and 9. (repeating distance d for 3 changes)
11. Change the temperature of the liquid by placing the tube of liquid into ice water (cold) or into a tub of warm water (hot) (if conditions permit).
12. Repeat experiment steps 4, *5, 6,* 7, 8, 9 and 10 for temperatures that are not the same as the original temperature.

E. CONSIDERATIONS

1. Determine the coefficient of viscosity of the liquid, in this case glycerin, by measuring the fall time of the balls in the liquid.
2. Find the equation of a straight line between T and r/R.

F. QUESTION

1. Determine the location of t h e wire bracelets encircling the selected tube (distance d). What will be the result if it is too high (close to the surface or too low (close to the bottom of the tube).
2. Calculate T^2_r for each ball and each d (use tables).
3. Calculate the graph between T^2 and d.
4. Calculate the price of η using the graph.
5. Prove that $T^2{}_r$ has a fixed price at the same d for different sizes Ball.
6. What is the benefit of calculating $_rT^2$ first to calculate the price of η?
7. Give the accuracy of this experiment for the results obtained.
8. What is the effect of temperature on the coefficient of viscosity of a liquid. Explain your answer.
9. Define the viscosity coefficient of substances in general
10. What is the unit of viscosity coefficient η in SI and what is the unit of η in c.g.s.
11. Prove formulas (6-2) and (6-3).
12. What is the result when the velocity of the ball is large relative to the fluid?
13. How can the price T_0 be determined from the graph?
14. If a bullet is fired upwards, is its velocity when it falls back the same as when it was fired? Explain your answer!

P5: SURFACE TENSION I

A. PURPOSE

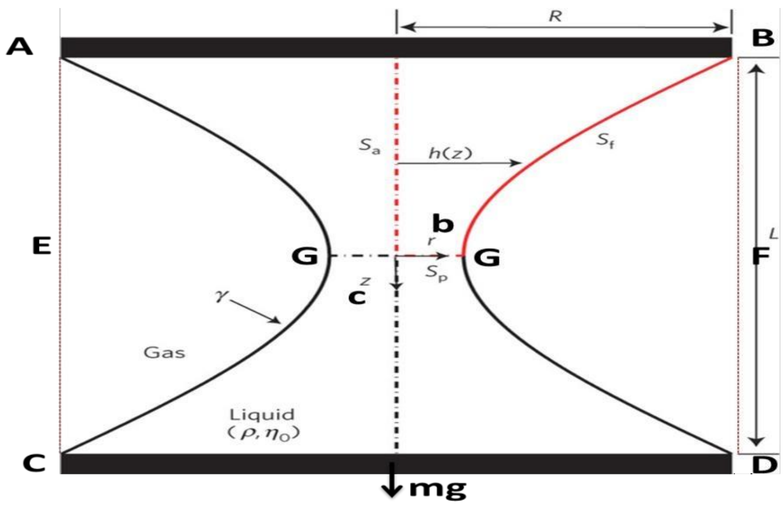
1. Understand the existence of forces on the surface of liquid or between the boundary and other materials
2. Determine the amount of surface tension of a liquid.

B. TOOLS AND MATERIALS

1. Two glass rods of equal length.
2. Yarn
3. Soapy water
4. Millimeter paper

C. BASIC THEORY

Two glass rods AB and CD are made equal in length and interconnected with two threads AC and BD. as shown in figure 1. below.



Surface tension 1

If the two glass rods that have been connected to the thread are dipped in soapy water then after lifting, there is a membrane between ABCD, where AC and BD are not perpendicular. See the position of the thread before dipping is A-E-C and B-F-D; while the position after dipping is A-G-C and D-H-B. By putting paper millimeters behind the membrane vertically, the smallest part G-H can be measured and after the membrane is broken, E-F can be read.

Suppose the rope tension at G and A is Dyne. The mass of the yarn and membrane is negligible CD. The weight of the system under the horizontal line E-F is mg, this force is resisted by the rope tension and membrane tension;

$$2N+2y \quad GH=mg \tag{1}$$

Suppose P and Q are two adjacent points on one of the ropes; and the radius of the curvature of the curved line PQ is r, while the angle formed between PQ and the center of the curve is θ.

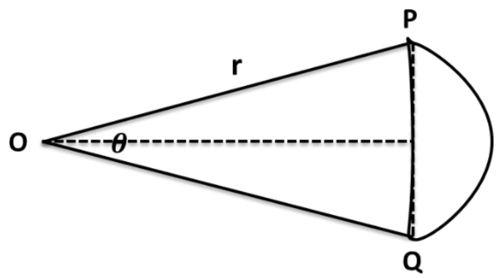


Figure 2. TP arch center 1

Angles POQ and PQ = $r\theta$. Since the weight of the thread is negligible and the tension of the soap film is always at right angles to the thread, the normal force N for any place on the thread is fixed. The tension on the thread along PQ is N sin θ which is proportional to the surface tension of the soap along PQ which is 2y PQ (from O to P).

So

$$N\sin\theta=2\gamma \, PQ \tag{2}$$

for small θ;

$$N = 2yr \tag{3}$$

Since N and T are constant, r is also constant, so AC and BD after the soap film forms a circle. By substituting equation (3) into equation (1) and if the distance G-H is known to be c,equation (1) can be written:

$$2lc + 4\gamma r = m.g \qquad (4)$$

Prove it

$$r = \frac{L^2}{4\,(b-c)} + \frac{1}{4}(b-c) \qquad (5)$$

where L is the distance of the AC straight at the time of the membrane. Thus:

$$\gamma = \frac{mg}{2(c+2r)} \qquad (6)$$

D. HOW IT WORKS

1. Weigh the glass rod several times and record the results.
2. Connect 2 glass rods of equal length with two threads of yarn as shown in Figure 1, with the length of the yarn 4 times the bonding distance on the glass rods.
3. Measure the distance between the two threads with the help of millimeter paper.
4. Dip the two glass rods that have been connected to the thread in soapy water, then lift the glass rods by holding one of the glass rods and close to the millimeter paper provided. Arrange the distance between the two arms and the distance between the two glass rods so that they can be measured accurately.Record the results of your measurements.
5. Perform steps (2) and (4) by changing the length of the yarn (longer than the previous experiment).
6. Change the yarn length 3 times.
7. Replace the soap water that has been used with new soap water. (Cold soap water & warm soap water). Then repeat steps (2) and (4).
8. Observe 10 times for each condition.

Don't forget to record the temperature each time (before and after the experiment).

E. CONSIDERATIONS

1. Calculate the surface tension of the soap solution you used for each solution tested.
2. Prove that the surface tension $\gamma = F/2l$ and explain the physical meaning of the formulation.
3. To what extent is the weight of the yarn negligible with respect to the glass rod.

4. Does the dimension of γ depend on pressure and temperature? Explain your answer.

F. QUESTION

1. Prove equations (5) and (6)!
2. Explain the difference in surface area increase mechanism between stretched soap film and pulled rubber.
3. Explain why a sliet or needle can float on the surface of water
4. If you have a spring pipe with a very small hole and you put the end in water, the water will rise up the pipe. Explain how this happens.

P6: SURFACE TENSION II

A. PURPOSE

Determine surface tension by method:

a. Maximum bubble pressure
b. Capillary rise

B. TOOLS AND MATERIALS

1. capillary pipe
2. glass vessels
3. open manometer
4. burette
5. erlenmeyer tube
6. bar
7. thermometer
8. screw micrometer

C. BASIC T E O R I

1. Surface Tension and Surface Power

The liquid molecules at the surface have greater cohesion than those inside. The attractive force with the molecules in the air above it is relatively very small. This causes special properties on the surface of the liquid, namely there is *surface tension or top plane tension.*

The surface tension H (more correctly called the surface tension coefficient) is the resultant of the cohesion force on the molecules of the surface layer per unit length. The units of H are dyne/cm and N/m.

To bring the liquid molecules from the interior to the surface, an effort is required against the cohesion force of the liquid surface. The effort required to increase the surface area per unit area is called *surface energy.* This surface energy is also given the symbol H, the units are erg/cm^2 and Joule/m^2 . The amount of *surface energy is the* same as the amount of *surface tension*, only the units are different.

2. Pressure on Curved Surfaces

On a curved liquid surface (boundary plane) there is additional pressure coming from the surface tension H. For a curved surface, the surface pressure is formulated:

$$P = K + H\left(\frac{1}{r_1} + \frac{1}{r_2}\right) \quad (1)$$

where K is the cohesion pressure, r_1 and r_2 are equal to the radii of the two principal curvatures. The price of r is positive when the surface is convex. For a positive P, it means the pressure is toward the inside of the liquid.

If the reaction force of the liquid itself is P', the direction is opposite to P, then the net P is

$$P_{netto} = P' - K - H\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

For a spherical surface of radius r ($r_1 = r_2 = r$), the above equation becomes:

$$P_{netto} = P' - K - \frac{2H}{r} \quad (3)$$

It's clear why the pressure of an air bubble inside a liquid increases the smaller the radius,

3. Contact angle, Meniscus and Capillary Rise.

If the cohesion force of the liquid is greater than the adhesion force of the liquid molecules with the wall, the surface will be balanced when the angle between the liquid surface and the wall is called obtuse. This angle between the liquid surface and the wall is called the contact angle. If the contact angle is obtuse, this event is called a convex meniscus. On the other hand, if the cohesion force of the liquid is smaller than the adhesion force, the contact angle is pointed, and this event is called a concave meniscus. For a liquid whose contact angle is obtuse, it is said that it does not wet the wall.

If a capillary pipe is dipped into a liquid that wets the wall, the liquid will rise as high as h, and it can be proven that:

$$h = \frac{2H \cos\theta}{\rho g r} \quad (4)$$

θ = contact angle

ρ = mass density
liquid

g = acceleration of gravity

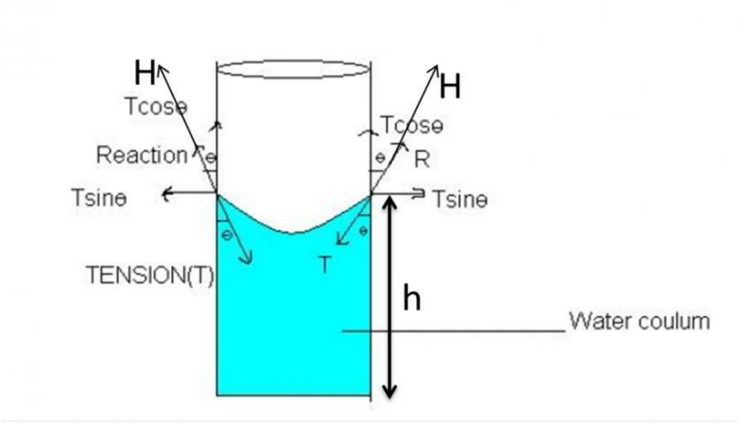
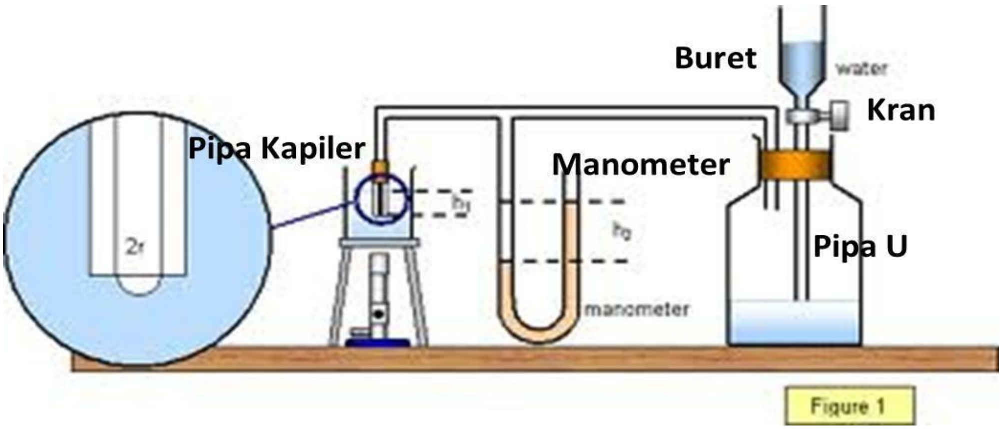


Figure 1. Contact angle

For water θ is very small, then cos θ =1, $h = \frac{2H}{gr}$ and H depends on temperature. H of a liquid gets smaller the lower the temperature. So H will equal 0 when the temperature is equalto the critical temperature t_k .

D. HOW IT WORKS



Experimental circuit of TP2

1. Preparation

a. The water in the U-pipe is in a minimal state.

b. The water on both legs of the open manometer should be the same height (h_0).

c. Fill the burette at the closed tap.

d. Fill the glass vessel with water.

2. **Experiment**
   a. Measure the distance from the bottom end of the capillary tube to where it will be immersed (h_z). Mark the distance.
   b. Dip the capillary tube to the mark.
   c. Open the burette tap, slowly.
   d. Pay attention to the dipped end of the capillary pipe, when the first air bubble comes out, record the position of the water level on the open leg of the manometer (h_m).

$$h_1 = 2(h_m - h_a)$$

   e. Measure the temperature of the water in the glass vessel to determine the price ρ_2 , and in the manometer to determine ρl, by matching the temperature price in the density table in the reference book.
   f. Do steps 4 and 5 five times.
   g. Repeat the experiment by changing the distance on the capillary pipe (different distance h_2). The distance h_2 was changed 3 times.

<u>Other methods:</u>

1) Remove the capillary tube on the tool set.
2) Clean the capillary pipe, try not to have any water bubbles left in the capillary pipe.
3) Dip the capillary tube into a glass filled with water perpendicularly.
4) Measure the water level inside and outside the capillary pipe for 5 times.
5) Repeat experiments 1 to 4 by adding water outside the capillary pipe. Add this water 3 times.

E. QUESTION

1. What is the maximum bubble pressure method in surface tension experiments!
2. Does surface tension depend on the temperature of the liquid used? Explain!
3. Derive the equation for determining surface tension by the bubble maximiun pressure method!

P7: DETERMINE THE JOULE CONSTANT

A. PURPOSE

To determine the equivalence number of heat and energy, the Joule constant.

B. TOOLS AND MATERIALS

1. Calorimeter and heating coil
2. AC Voltmeter and AC Ammeter
3. Transformer (Step Down)
4. Shear resistance or rheostat
5. Circuit breaker
6. Watches
7. Thermometer

C. BASIC THEORY

Energy can be found in various forms. Changes in physical processes are often changes in energy from one form to another, for example, changes in electrical energy to heat energy, changes in mechanical energy to heat energy or vice versa. If W is the energy expressed in Joules and Q is the amount of heat that arises as a release and is expressed in calories then the equivalence number or Joule constant (J) is expressed:

$$J = W/Q \qquad \text{Joule/calorie} \qquad (1)$$

If a quantity of water whose mass (M_a), temperature (t_a), is in a calorimeter whose heat acceptance price (H = Mk.Ck), is heated to a temperature t_m , then the amount of heat received by the water and the calorimeter is:

$$Q=(M +H)(t_m - t_a) \qquad \text{calories} \qquad (2)$$

The amount of heat can be the dissipation of electrical power or mechanical power. Resistance in an electrical circuit is similar in nature to friction in mechanical systems. With the electric current passing through a prisoner, the temperature of this prisoner will rise, as a result of electric power dissipation. This power dissipation is expressed in the following equation:

$$W = V\,I\,t \qquad \text{Joules} \qquad (3)$$

V = voltage difference between the two ends of the prisoner (Volt)

I = current passing through the prisoner (Ampere)

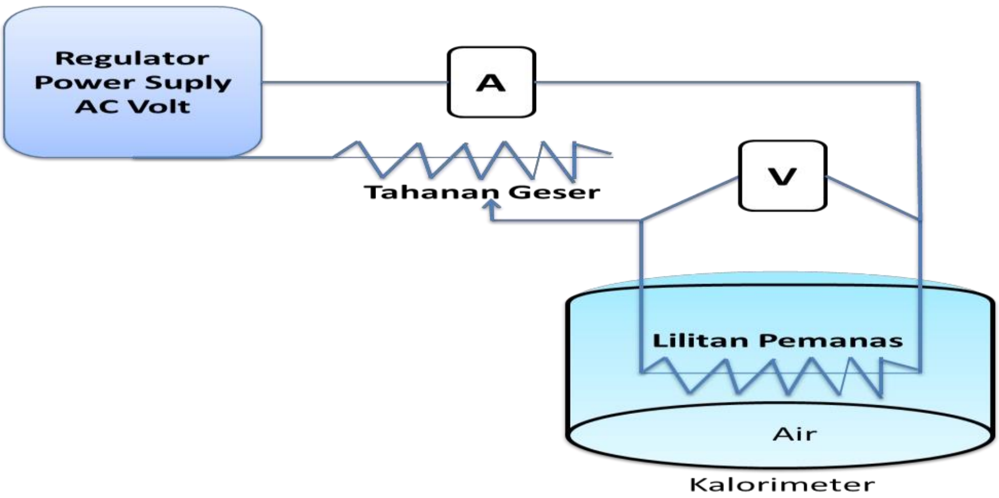
t = time interval which states the length of time the prisoner is passed by the current (seconds).

In this experiment, a certain amount of water is put into a calorimeter, then a heating coil is dipped into it, so that when this coil is electrified enough, heat is generated which is able to raise the temperature of the water, for example from t_a to t_m The amount of heat required for that is expressed by equation (2). Thus the Joule constant can be calculated from thefollowing equation:

$$J = V\,I\,T \qquad \text{Joule/calorie} \quad (4)$$

$$(M_a + H)(t_m - t_a)$$

The arrangement of the tools in this experiment can be seen in Figure 1 below:



Experimental circuit

D. HOW IT WORKS

1. Assemble the electrical circuit according to the picture above. Do not connect to a current source before being checked by an assistant.
2. After checking, connect the circuit to an AC current source; close the circuit breaker and adjust the sliding resistance so that a large enough current is read, after which the breaker is opened again.

3. Weigh an empty calorimeter. Then fill in enough water, so that the heating coil can be submerged. Then weigh the calorimeter filled with water again; thus the mass of water can be calculated.
4. Chill the calorimeter in a refrigerator or ice flask, until its temperature drops a few degrees below room temperature.
5. Set the calorimeter in place, stirring gently until the desired starting temperature is reached. Surrounding heat exchange is unavoidable. But this can be minimized, for example, by starting the experiment with a starting temperature lower than room temperature and ending at a temperature higher than room temperature with the same temperature difference, for example: Room temperature = 30^0 C. If the experiment starts at 29^0 C, then the experiment ends at 31 C.^{0}
6. When the desired initial temperature is reached close the circuit breaker (when the second hand of the watch points to zero). Record the potential difference V and current I every 30 seconds. During observation the ampermeter designation is kept constant. If there is a decrease / increase, the rheostat is shifted until the ampermeter designation returns as before. The water in the calorimeter is always stirred slowly.
7. After the desired final temperature is reached open the circuit breaker and record the specified time Record the final temperature as well.
8. Repeat steps 3 to 7 by taking a different mass of water.

E. CONSIDERATIONS

1. Find the equality value of heat and energy based on your observations.
2. Calculate the Joule constant (with error).
3. Look up the standard Joule constant in Physics books.
4. Is the standard rate in your calculation region? If not, explain why this might be the case, explaining why!

F. QUESTION

1. Explain what is meant by specific heat capacity
2. If water with a mass of 250 grams at a temperature of 28 C is put into a vessel, then given electricity through a 60 watt wire coil for 2 minutes. If only water absorbs heat, what is the temperature of the water now.

P8: HEAT CONDUCTIVITY

A. PURPOSE

Determine the heat conductivity (K) of a sheet of substance that has weak conductivity.

B. TOOLS AND MATERIALS

1. Heating vessel
2. Copper heat receiver
3. Thermometer
4. Substance sheet
5. micrometer
6. Scope
7. Heater

C. BASIC THEORY

The amount of heat per unit time delivered from a heat source with temperature T_1 to a heat receiver with temperature T_2 through a conductor whose cross-sectional area is A andthickness is d, can be written as follows:

$$\frac{dQ}{dT} = KA\left[\frac{T_1 - T_2}{d}\right]$$

If the temperature of the receiver is higher than the temperature of its surroundings, it will emit heat per unit time:

$$\frac{dQ}{dt} = mc\left[\frac{dT}{dt}\right]_2$$

m = receiver mass

c = spefisic heat

$\frac{dT}{dt}$ = temperature drop per unit time

In a steady state, the amount of heat received must be equal to that emitted, so equations 1 and 2 become:

$$KA = \left[\frac{d}{T_1 - T_2}\right]' mc\left[\frac{dT}{dt}\right]_2$$

$$KA = \left[\frac{dT}{dt}\right]_2 \frac{d}{A[T_1 - T_2]}$$

The number 2 in $\left[{}^{dT}/_{dt}\right]$ shows the temperature reduction at unit-time receiver at the time of temperature T, which is the balanced temperature.

D. HOW IT WORKS

1. Measure the thickness of the substance sheet, the diameter, and the mass of the receiver.
2. The water in the vessel is heated so that it is at boiling temperature T_1
3. Set the device as shown in Fig.(2). Measure the temperature of the heat receiver until the temperature no longer rises for 5 minutes (This is called steady state). The temperature at that time is named T
4. The substance sheet is removed and the receiver is directly heated until the temperature is T_2 + *5 C.*^{0}
5. By moving the heating vessel, the substance sheet is placed back on the receiver.
6. Every 30-second interval take temperature data for temperature changes from $T_2 + 3^0$ C to $T_2 - 3^0$ C. so that the temperature drop at steady state can be calculated.

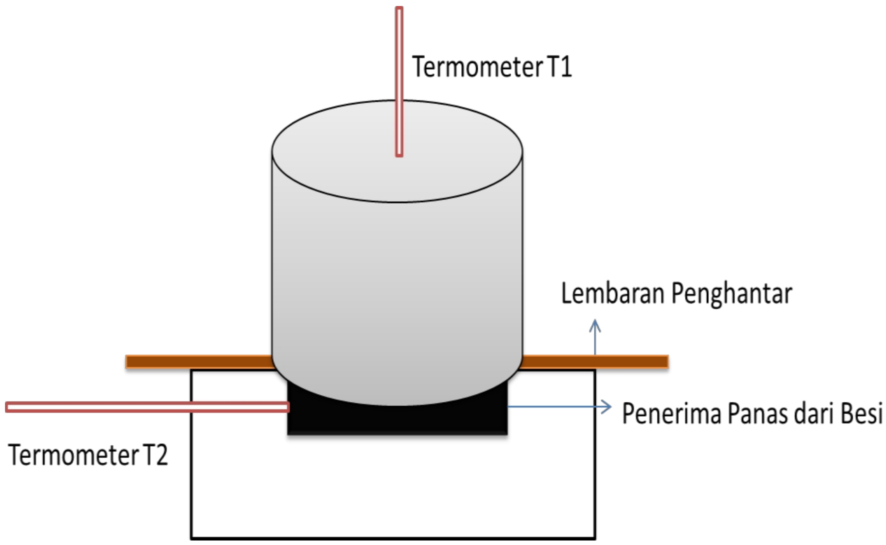


Figure 1. Heat conductivity experiment circuit

E. CONSIDERATIONS

1. Calculate the price of K in the MKS system.
2. Draw a graph between T and t at the receiver and determine $\left[\frac{dT}{dt}\right]_2$
3. Provide conclusions from the results of the experiment and what factors can cause inaccuracy in this experiment.
4. Find the amount of heat conductivity for the sheets you used in the practicum. Comment on your calculations with the results obtained from the reference.

There must be full water vapor on the surface; hence there is continuous evaporation on that end surface.

The temperature of the wet end must be lower than the ambient temperature in order for heat to be transmitted from the surroundings to this end. Based on this line of thought Clark Maxwell calculated the mass of water vapor evaporated per second, which depends on the difference between the vapor pressure at the surface of the wet end and the vapor pressure of the surrounding water and also depends on the diffusion constant, then also calculated the amount of heat per second received by the wet end from the surroundings by transmission and emission, which depends on the conductivity and conductivity of the air and the difference between the temperature at the surface of the wet end and the temperature at the surface of the wet end and the surrounding temperature. This amount of heat must be equalto the heat required for evaporation. From the above reasoning, the equation is derived:

$$P = P_m - 0.00066\ B\ (t - t\ )_b \quad (1)$$

Where

p =pressure of water vapor in air

p_m =maximum water vapor pressure at air temperature

B = barometer

t =temperature indicated by a dry thermometer t_h

=temperature indicated by a wet thermometer.

As for the other way by using a dew-point hygrometer, a tube with a shiny outer wall, ether and a thermometer are inserted, ether is forced to evaporate by blowing air into this tube. As a result the temperature drops and this can be read on the thermometer. The decrease in temperature occurs continuously until one day peagembunan (reaching the dew point). On the outer wall of this tube there is a gloom on the shiny part.

P9: AIR HUMIDITY

A. PURPOSE

1. Understand the working principle of a hygrometer
2. Using a hygrometer to determine the air humidity of a room.

B. TOOLS AND MATERIALS

1. Rotary hygrometer (sling hygrometer)
2. Dew point hygrometer
3. Thermometer

C. BASIC THEORY

Air humidity is a measure of the amount of water vapor in the air. When the pressure of water vapor in the air reaches a maximum, condensation begins to occur. For example, air containing water vapor with a persial pressure of 17.55 mmHg, and the air temperature is 30°C; the maximum pressure at 30°C is 31.86 mmHg (See Table 1). So, the partial pressure by water vapor is still below its maximum pressure, so no condensation occurs. If the air temperature becomes 20 °C, condensation begins to occur, because the maximumpressure of water vapor at 20 °C is 17.55 mmHg.

If the air temperature continues to fall, for example to 18°C, clouds and rain occur, reducing the number of water vapor molecules in the air to such an extent that the water vapor pressure in the air does not exceed the maximum pressure. With condensation and rain theair pressure will not exceed 15.49 mmHg, because the maximum pressure of water vapor at 18°C is 15.49 mmHg.

Absolute humidity is the mass of water vapor in air per unit volume. *Relative humidity* is the ratio between the mass of water vapor in air per unit volume and the mass of water vapor per unit volume, if the pressure is equal to the maximum pressure of water vapor at air temperature. By relating mass to pressure, the following equation can be obtained:

$$\text{Kelembaban relatif} = \frac{\text{tekanan uap air dalam udara}}{\text{tekanan maksimum uap air pada temperatur udara tsb}}$$

Table 1. Air Humidity

T c°	**P_m**	**ρ_m x 10^{-8}**	**c**	**P_m**	**ρ_m x 10^{-8}**
10	9,21	9,40	22	19,84	19,43
11	9,85	9,40	23	21,09	20,58
12	10,52	10,66	24	22,40	21,78
13	11,24	11,35	25	23,78	23,25
14	11,99	12,07	26	25,24	24,38
15	12,79	12,83	27	26,37	25,77
16	13,64	13,63	28	28,37	27,23
17	14,54	14,48	29	30,08	28,78
18	15,49	15,37	30	31,86	30,37
19	16,49	*16,31*	31	33,70	32,21
20	17,55	17,30	32	35,70	34,05
21	1866				

Description:

t = temperature,

P_M = maximum pressure of water vapor (mm Hg),

ρ_m = mass density of full water vapor in grams/cm

There are several ways to determine the humidity of the air around the room, including with a sling hygrometer. Sling hygrometer is made of two thermometers with one end moistened with water and the other dry, placed on a rod that is rotated quickly This has the same effect as putting the two thermometers in a place where the wind blows strongly. It will be seen that the wet thermometer will show a lower place than the dry one This is because around the wet end the water vapor is saturated, while some distance away the water vapor pressure is much smaller. So the water vapor molecules near the wet tip move outward away from the tip, that is, from a dense place to a less dense place. But the tip is always wet, so in an equilibrium state There must be full water vapor on the surface; hence there is continuous evaporation on that end surface.

The temperature of the wet end must be lower than the ambient temperature in order for heat to be transmitted from the surroundings to this end. Based on this line of thought Clark Maxwell calculated the mass of water vapor evaporated per second, which depends on the difference between the vapor pressure at the surface of the wet end and the vapor pressure of the surrounding water and also depends on the diffusion constant, then also calculated the amount of heat per second received by the wet end from the surroundings by transmission and emission, which depends on the conductivity and conductivity of the air and the difference between the temperature at the surface of the wet end and the temperature at the surface of the wet end and the surrounding temperature. This amount of heat must be equalto the heat required for evaporation. From the above reasoning, the equation is derived:

$$P = P_m - 0.00066\ B\ (t - t_b) \tag{1}$$

Where:

p = pressure of water vapor in air

p_m = maximum water vapor pressure at air temperature

B = barometer

T = temperature indicated by a dry thermometer

t_h = temperature indicated by a wet thermometer.

As for the other way by using a dew-point hygrometer, a tube with a shiny outer wall, ether and a thermometer are inserted, ether is forced to evaporate by blowing air into this tube. As a result the temperature drops and this can be read on the thermometer. The decrease in temperature occurs continuously until one day condensation (reaching the dew point). On the outer wall of this tube there is a gloom on the shiny part.

D. HOW IT WORKS

a. Using a rotary hygrometer sling

1. smear one end of the thermometer with water and leave the other dry.
2. rotate the hygrometer quickly for a while (this effect is the same as putting both thermometers in a place where the wind is blowing strongly), record the temperature that occurs on the two
3. repeat step 2 for 5 times

b. Using a dew-point hygrometer

1. Fill the tube with ether and the thermometer on the tube cap
2. Pump the rubber ball slowly and always observe the outer wall of the tube as well as the thermometer.
3. Stop the pump when the tube wall starts to become dull with dew. Record the temperature at this point, as well as when the dew starts to disappear. This temperature is the vapor dew point limit
4. Also record the ambient temperature for each dew point reading.
5. repeat steps 2 to 5 5 times

E. CONSIDERATIONS

1. From the observations of t, tb, B in workings part a and the readings in table I for Pm and density of water vapor, calculate
   a. relative humidity
   b. dew point
   c. absolute humidity
2. From an experiment using a dew-point hygrometer calculate:
   a. relative humidity
   b. absolute humidity

F. QUESTION

1. State the definition of absolute humidity and relative humidity.
2. What is the relationship between maximum water vapor pressure and dew point?
3. What is saturated water vapor and how does it relate to air humidity?
4. What is the relationship between maximum water vapor pressure and dew point?

5. What is saturated water vapor and how does it relate to air humidity?
6. What is the relationship between maximum water vapor pressure and dew point?

P10: FLOW CALORIMETER

A. PURPOSE

Determine the tare or mechanical heat equivalence factor with a flow calorimeter.

B. TOOLS AND MATERIALS

1. Calorimeter Tube
2. Measuring cup
3. Regulator (Rg)
4. 0-5A Ammeter
5. Rheostat (Rh)
6. Water Vessel
7. Thermometer 2 pieces
8. Voltmeter
9. Stop watch

C. BASIC THEORY

A calorimeter is a device used to measure the amount of heat, one type of calorimeter is a flow calorimeter. The flow calorimeter works by flowing water continuously from the vesselinto the calorimeter tube containing the heating element through one end and removing the water at the other end. The heating element is supplied with a current i A with a voltage V. The continuous flow of water causes a temperature difference at both ends of the calorimetertube. By measuring the mass of the escaping water, the amount of heat can be calculated based on the following equation:

$$Q = m\ c\ (T_2 - T_1) + h \text{ (calories), or } m\ c\ \theta + h \quad (1)$$

Where

m = mass of water,

c = calorific value of water,

Θ = temperature difference;

h= correction factor.

The amount of heat generated is proportional to the heat applied by the electric current during t seconds of the experiment.

$$W = Vit \text{ joule } (2)$$

So equation (1) is comparable to equation (2)

$$Vit \cong (mc\theta + h), \text{ or } Vit = j(mc\theta + h) \quad (3)$$

where j is called the mechanical heat rate (joules/calories).

By experimenting with a different current (i' A) for the same t seconds, the difference between equations (3) and (4) becomes:

$$V'\, I'\, t = j\,(m'\, c\, \theta' + h) \quad (4)$$

from the difference of equations (3) and (4) is obtained;

$$J = \frac{t\left(V.i - V'i'\right)}{c\left(m\theta - m'\theta'\right)} \quad (5)$$

D. HOW IT WORKS

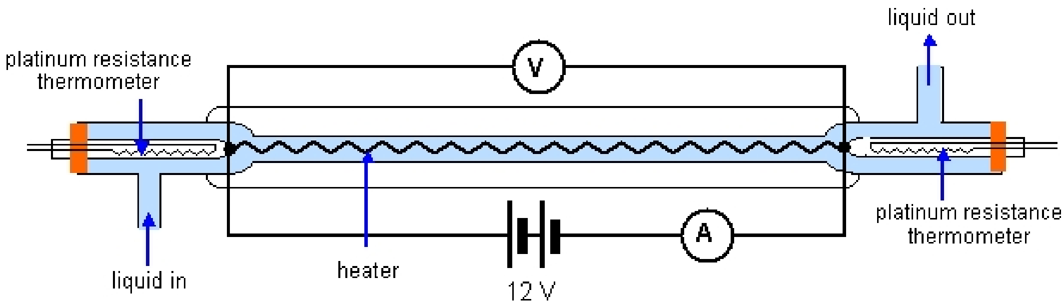


Figure 1. Flow Calorimeter circuit

1. Fill the calorimeter tube with water until there is no air in it and the water level is at the end of the outlet pipe.
2. Assemble the apparatus according to figure (2). Discuss with the assistant before connecting it to the current source.
3. Run the water in the tube continuously and set the electric current at 1.5 A.
4. After the temperatures T_1 and T_2 are fixed with the smallest possible difference (e.g. 5°) the water coming out of the calorimeter tube is collected for 2 minutes. Data for water mass and temperature (T_1 and T_2) as well as V and i can thus be obtained.
5. Repeat the above experiment by setting the current to 2A; 2.5A; 3 A

E. CONSIDERATIONS

Determine the mechanical heat rate (j) and give your interpretation.

F. QUESTION

1. Look up the mechanical heat rate in a reference book; give your analysis if there is a difference with the results of your experiment.
2. Explain why the difference between θ and θ' should be as small as possible!
3. Derive equation (5)

SPECIAL EDITION

USING JEULIN TOOLS

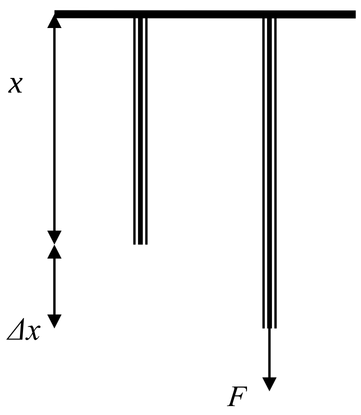
HOOKE LAW

I. Practicum Objective

1. Understand the concept of Hooke's law
2. Determine the magnitude of the spring constant
3. Analyzing the relationship between restoring force and spring length increase

II. Basic Theory

Hooke's Law basically describes the elastic properties of an object when subjected to a force (called the restoring force), which is a condition where an object will tend to return to its initial state when the force is removed. The elastic properties of objects can be studied by pressing or stretching the object so that it experiences an increase in length through a force so that if the force is removed, the length of the object will return to its initial length.



A wire that increases in length after being subjected to a force

According to Hooke's law, the relationship between the restoring force and the increase in length of an object is given by the formula :

$$F = -k\Delta x \quad (1)$$

with

F: restoring force (N)

Δx: length increment (m)

k : elasticity constant of the object (N/m)

From equation (1) we can deduce that the restoring force is directly proportional to the increase in length and the negative sign indicates that the restoring force has the opposite direction to the increase in length.

Theoretically, the constant in equation (1) can be associated with several quantities that describe the elasticity properties of an object. According to basic physics concepts [1, 2], all objects that experience a change in length will have another constant known as Young's modulus so it will be proven that the elasticity constant of materials can be formulated:

$$k = \frac{YA}{x} \quad (2)$$

with

Y : Young's modulus (N/m)^2

A: cross-sectional area of the object (m)^2

In this practicum, we will try to calculate the constant value by using a table that contains the relationship between the force exerted on the spring and the resulting length increase. The applied force will be recorded by the force sensor while the spring length increase is measured manually. Thus, the practitioner will present some data in the form of a table of the relationship between the restoring force and the increase for each one of the experimental data, and then graph the relationship between the two quantities. Through equation (1), the slope of the straight line is the spring constant obtained.

III. Preliminary Task

1. Derive the formula of equation (2)
2. Look up in another reference book what is the Young's modulus of an object.
3. What happens when an object is pulled with a force that exceeds its elasticity limit?

IV. Tools and Materials

1. VTT console
2. force sensor
3. spring
4. ballast
5. ruler

V. Experiment Steps

a. Arrange the experiment circuit as shown in Figure [3]

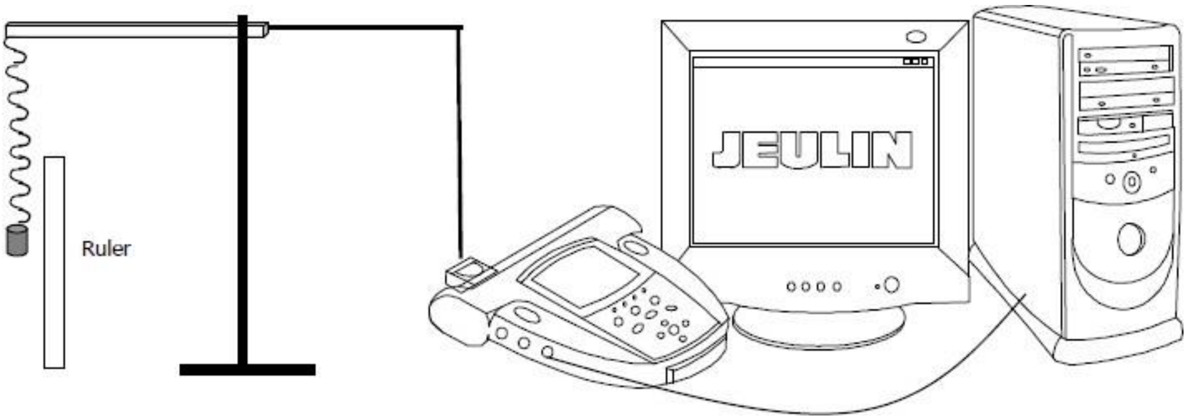


Figure 2. Hooke's law experiment set-up

b. Set the parameters in the software (will be explained during the practicum)

c. Load the spring with different weights (do this at least five times)

d. Graph a straight line on the computer, then observe the slope of the line

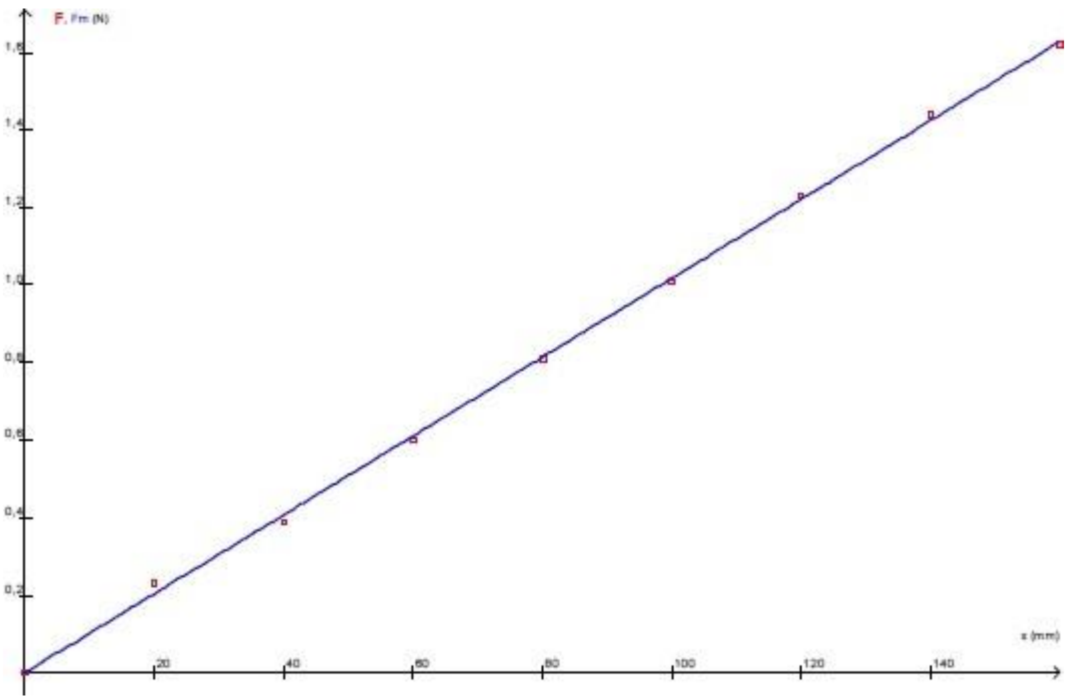


Illustration of the graphical results obtained

e. Repeat the above experiment by replacing another spring, then compare the results obtained with the previous results.

VI. Final Project

a. Write the experimental data and calculate the spring constant for each spring used into the following table (take 5 experimental data)

No.	Length Gain	Style

b. Copy the recorded data and graph (will be explained during the practicum)

c. Analyze and conclude

Reference

1. Abdullah, M. (2007). Basic Physics Lecture Dictate I, Bandung: Bandung Institute of Technology.
2. Tipler, P.A. and Mosca, G. (1997). Physics for Scientists and Engineers,5th ed., California: Freeman Publishers.
3. Jeulin practicum module.

NEWTON'S LAW II

I. Practicum Objectives

1. Understand the concept of Newton's second law
2. Determine the acceleration of an object on an inclined plane
3. Model the position of objects for each time

II. Basic Theory

In the dynamics of motion, the cause of the motion of an object is a force that is both conservative and non-conservative. The existence of the force acting on the objectcauses a physical quantity known as acceleration. In general, to study the dynamics of motion of an object experiencing acceleration, Newton's second law is used, which is mathematically written [1, 2].

$$\vec{F} = m\vec{a} \qquad (1)$$

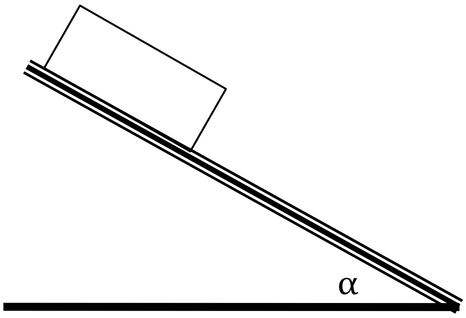
with

$\vec{F}$: force (N)

m : mass of the object (kg)

$\vec{a}$: acceleration of the object (m/s)^2

Equation (1) describes an equation of motion of an object in an arbitrary dimension. The mass of the object (in this case a fixed value) in equation (1) is known as the constant of inertia, which is a constant that affects the ease or difficulty of the object to move. In this practicum we only focus on the case of point objects, which are objects whose magnitude can be ignored but whose mass cannot be ignored.



One example of the application of Newton's second law to the motion of objects on an inclined plane

The thing that must be remembered is that first all the force components imposed on the object must be described to study the dynamics of the equation of motion of the object formulated through Newton's second law. This aims to facilitate the analysis of the motion of the object. In addition, from the point of view of motion kinematics, the magnitudes of motion can be formulated as follows

$$\vec{r}(t) = \vec{r}(0) + \int \vec{v}(t)dt \qquad (2)$$

$$\vec{v}(t) = \vec{v}(0) + \int \vec{a}(t)dt \qquad (3)$$

$\vec{r}(t) = position\ of\ the\ object\ at\ each\ time\ (m)$
$\vec{r}(0) = initial\ positionof\ the\ object\ (m)$
$\vec{v}(t) = velocity\ of\ the\ object\ at\ each\ time\ (m/s)$
$\vec{v}(t) = initial\ velocity\ of\ the\ object\ (m/s)$

In this practicum, we will model the formula for the position of objects through the graphs obtained by first assembling an experimental device for the motion of objects on an inclined plane. In addition, all data on physical quantities are not obtained manually but from the sensors used.

III. Preliminary Task

1. Derive the formulas of equations (2) and (3)
2. Derive the equations for the position and velocity of an object on an inclined plane with an angle of inclination α

3. What is the difference between a point body and a rigid body

VII. TOOLS AND MATERIALS

1. *VTT console*
2. *chrono-cine* sensor
3. *power supply*
4. inclined plane
5. ruler

IV. Experiment Steps

1. Arrange the experiment circuit as shown in Figure [3]

Figure 2. Experimental circuit of Newton's second law in the case of an inclined plane

2. Set the sensor location in such a way (will be explained during the practicum)
3. Make a graph through software (will be explained during the practicum)
4. Make a mathematical model of the position and velocity equations and compare it theoretically.

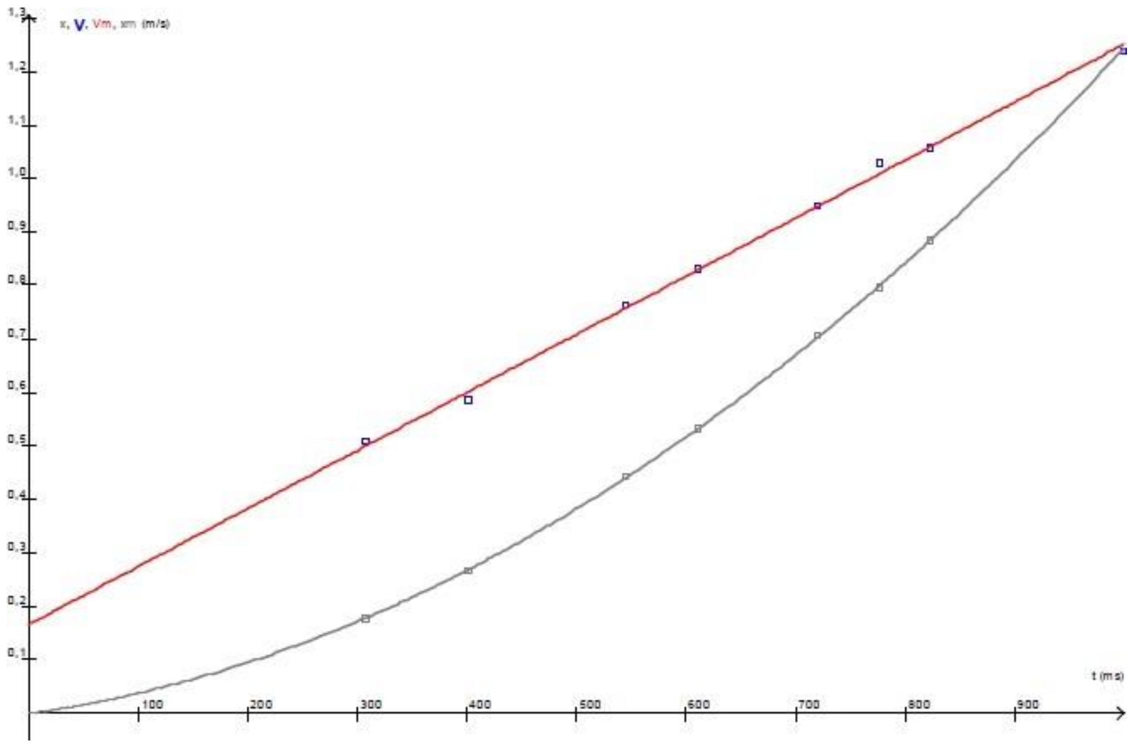


Illustration of the graphical results obtained

5. Repeat the above experiment by changing the position of the sensor, then compare the results obtained with the previous results

V. Final Project

1. Copy the recorded data and graph (will be explained during the practicum)
2. Create mathematical models for position and velocity
3. Analyze and conclude

Reference

1. Abdullah, M. (2007). Basic Physics Lecture Dictate I, Bandung: Bandung Institute of Technology.
2. Tipler, P.A. and Mosca, G. (1997). Physics for Scientists andEngineers, 9th ed., California: Freeman Publishers.
3. Jeulin practicum module.

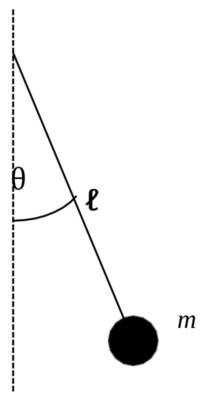
SIMPLE PENDULUM

I. Practicum Objective

1. Understand the basic principles of a simple pendulum
2. Understand the relationship between a simple pendulum and oscillatory motion
3. Understand oscillation patterns for small angles of deviation

II. Basic Theory

In basic physics oscillation is a simple back and forth motion towards an equilibrium point and in general there are many ways to study oscillation patterns. In this lab, we willstudy the oscillation pattern of a simple pendulum with a small angle.



Simple pendulum

In simple terms, if an object in a simple pendulum system is deviated by a small angle, then by using Newton's second law, the solution of the equation of motion will be obtained in the form of a deviation angle which can be formulated mathematically [1, 2].

$$\theta(t) = \theta_{max} \sin(\omega t + \varphi) \quad (1)$$

or

$$\theta(t) = \theta_{max} \cos(\omega t + \varphi) \quad (2)$$

with

$\theta(t)$: angle of deviation (rad)

θ_{max}: maximum deviation (rad)

ω : angular frequency (rad/s)

φ : initial phase angle

Equation (1) or (2) is only valid for small angles while for rather large angles, nonlinear factors appear. In this practicum, we only study the case of point bodies and small angles. In addition, the solution to equations (1) or (2) can only occur if the pendulum system is considered a point body. For the case of a rigid body, the calculation of the moment of inertiaof the suspended body must be done with respect to its center of mass using the parallel axis theorem. Through the angular frequency in equation (1) or (2), we will also get the formulation of the pendulum period *(T)* which is defined as the time required to travel onefull path.

$$\omega = \frac{2\pi}{T} \quad (3)$$

with

$$T = 2\pi\sqrt{\frac{\ell}{g}} \quad (4)$$

With g is the acceleration of gravity. In this practicum, we will prove the correctness of the position deviation equation formula (1) through the graph obtained by first assembling an experimental device for a simple pendulum system. At

In addition, all physical quantities data $\theta(t)$ and T are not obtained manually but rather from the sensors used.

III. Preliminary Task

1. Derive the formula of equation (1) or (2)
2. Why does the solution to equation (1) or (2) only apply to small angles and point bodies
3. Derive equation (4) (hint: use Newton's second law for rotation)

IV. TOOLS AND MATERIALS

1. VTT console

2. A set of simple pendulum systems

3. ballast

4. angle sensor
5. ruler

V. Experiment Steps

1. Arrange the experiment circuit as shown in Figure [3]

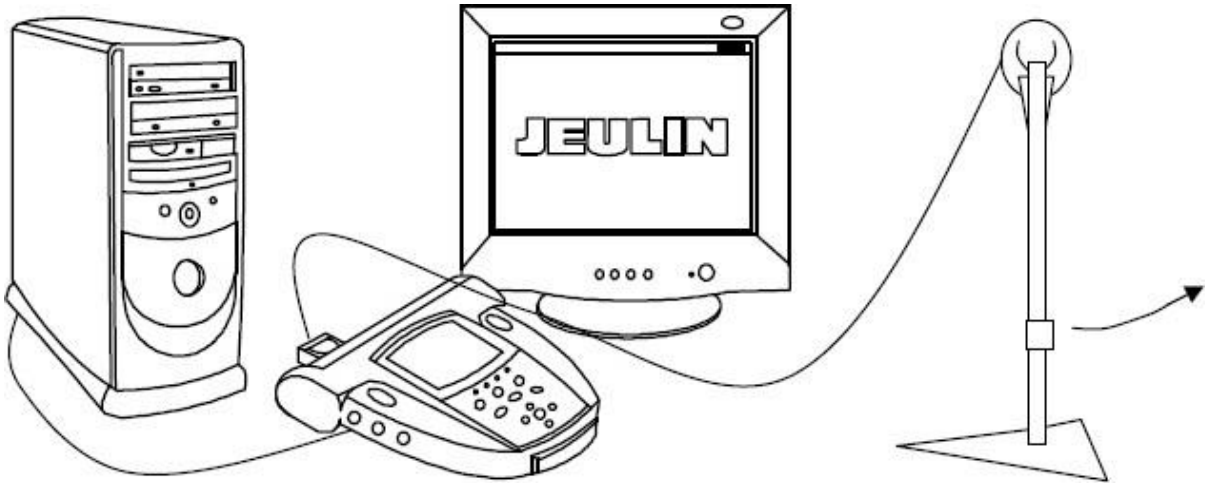


Figure 2: Experimental circuit of a simple pendulum system

2. Measure the length of the rope, then give it a small deviation (use a protractor) of maximum $15^{o,}$

   done by taking different values of θ
3. Make a graph through software (will be explained during the practicum)
4. Analyze the graphs obtained for different values of θ.

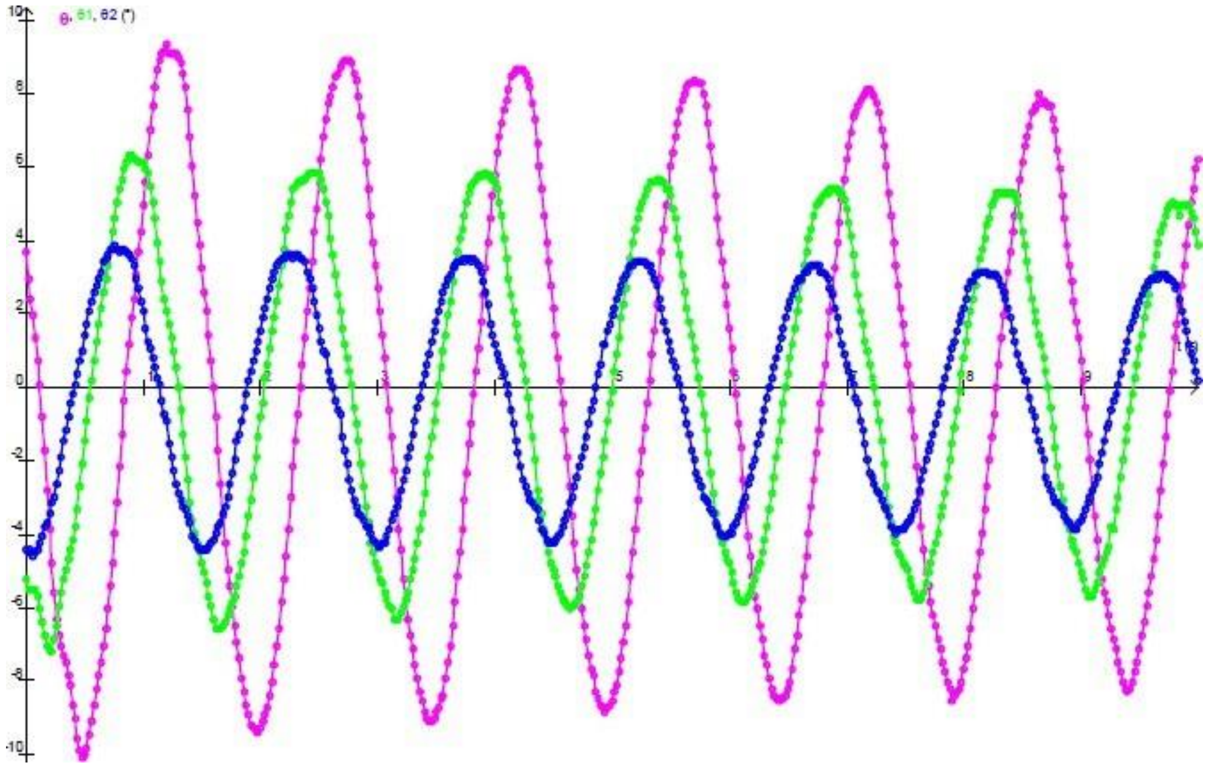


Illustration of the graphical results obtained

5. Repeat the above experiment by changing the mass of the weight, then compare the results obtained with the previous results whether the graph pattern has changed or not.

VI. Final Project

1. Copy the recorded data and graph (will be explained during the practicum)
2. Create a mathematical model for the angular deviation equation listed in equation (1) or (2).
3. Analyze and conclude

Reference

1. Abdullah, M. (2007). Basic Physics Lecture Dictate I, Bandung: Bandung Institute of Technology.
2. Tipler, P.A. and Mosca, G. (1997). Physics for Scientists andEngineers, 9th ed., California: Freeman Publishers.
3. Jeulin practicum module.

SOUND WAVES

I. Practicum Objective

1. Understand the concept of sound wave propagation
2. Determine the speed of propagation of sound waves experimentally
3. Analyze the difference between the results of the calculation of the speed of propagation of sound waves in theory and experiment.

II. Basic Theory

Sound waves are classified as mechanical waves, which are waves that can only propagate in a medium. In general, sound waves can occur when the particles of a medium vibrate so that the energy of sound waves can propagate in the medium [1, 2]. At room temperature, which is around 20^{o} C, the speed of propagation of sound waves is generally determined by the type of medium through which it passes. The followingtable shows the speed of propagation of sound waves at room temperature for several mediums [1].

Medium	**Velocity of Creation (m/s)**
Air	343
Helium	1005
Hydrogen	1300
Water	1440
Sea water	1560
Glass	4500
Aluminum	5100

Table 1. Wave propagation speed in several mediums

The strength of a sound wave describes the amount of energy carried by the wave. Generally, the quantity to measure the strength of a sound wave is known as the intensity of the sound wave, which is formulated as follows

$$I = \frac{P}{A} \quad (1)$$

with

I : sound wave intensity (Watt/m)[2]

P : sound wave power (Watt)

A: surface area traveled by sound waves (m)[2]

From equation (1), we can conclude that I can become very large when P and A *are* changed in such a way. Therefore, to avoid writing such a large number, a new quantity, the intensity level, is usually used.

$$\beta = 10 \log \frac{I}{I_0} \quad (2)$$

with

β : intensity level

I : intensity of the sound wave

I_0 : threshold intensity of sound waves (10^{-12} W/m^2)

The number 10^{-12} in the sound wave intensity threshold value refers to the lowest sound intensity that can be heard by the human ear, another reference can be seen in [3].

In this practicum, we will try to measure the speed of propagation of sound waves in the air. In essence, the propagation speed of sound waves is not only determined by the type of medium, but also by the surrounding temperature and pressure. In general, the formulation of the speed of propagation of sound waves in air can be formulated empirically by the equation [4].

$v = 331.5 + 0.607\,T$ (3)

where T is the ambient temperature in Kelvin.

III. Preliminary Task

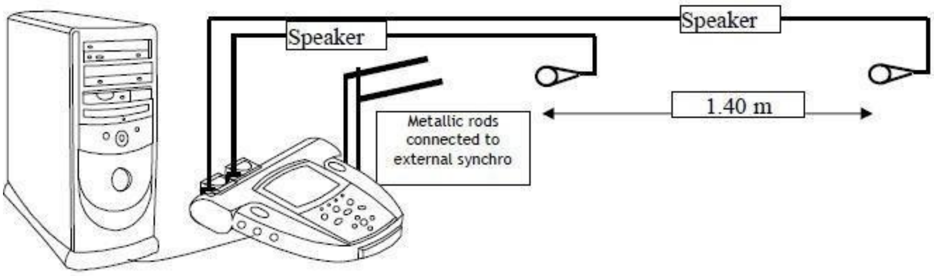
1. Explain the difference between vibrations and waves
2. Write down one example of a wave function and its physical interpretation
3. What are the assumptions used in formula (3)

IV. Tools and Materials

1. VTT console
2. VTT voltmeter adapter
3. two microphones
4. two metal rods
5. ruler

V. Experiment Steps

1. Arrange the experiment circuit as shown in Figure [4]

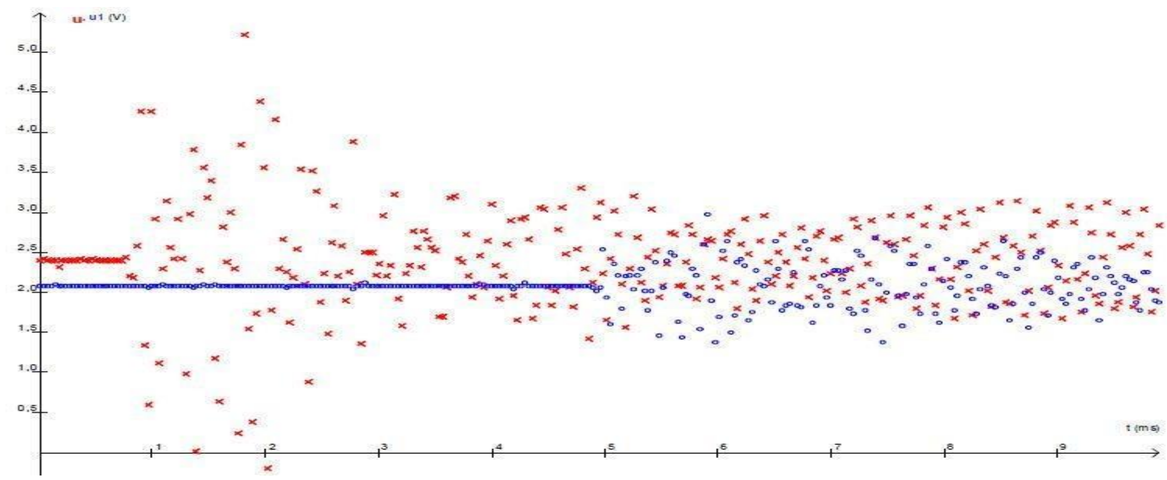


2. Set the parameters in the software (will be explained during the practicum)
3. Bang the two rods as hard as possible on one end of the microphone
4. Observe the patterns of sound distribution on a computer monitor
5. Calculate the speed of sound propagation obtained by using the formula

$$v = \frac{d}{\Delta t}$$

where *d* is the distance between the two microphones and *Δt* is the time difference of the two microphones

For example, suppose we get the following sound distribution patterns



Picture 1. Illustration of the resulting sound distribution

then Δt obtained by subtracting the length of the blue line and the length of the red line on the horizontal axis

6. Repeat the experiment by changing the distance of the two microphones

VI. Final Project

1. Write the experimental data and calculate the sound propagation speed for each data into the following table (take 5 experimental data)

No.	Microphone Distance	Fast Creepage

2. Copy the data recorded on the microphone and its graph (will be explained during the practicum)
3. Analyze and conclude

Reference

1. Abdullah, M. (2006). Lecture Dictates of Basic Physics II, Bandung: Bandung Institute of Technology.
2. Tipler, P.A. and Mosca, G. (1997). Physics for Scientists and Engineers, 9th ed., California: Freeman Publishers.
3. Pain, H.J. (2005). The Physics of Vibrations and Waves, 6thth ed., New York: John Wiley & sons.
4. Jeulin practicum module

ENERGY THEOREM

I. Practicum Objective

1. Understand the concept of effort and energy theorem
2. Understand the difference between conservative and non-conservative forces
3. Use the application of effort and energy theorem in simple cases

II. Basic Theory

In some cases, the discussion of the motion of objects traveling on an arbitrary trajectory is generally very difficult when studied through Newton's laws. This is due to the shape of the trajectory that is no longer straight so that the depiction of non-conservative forcesis difficult to do [1, 2].

Conservative style	Non-conservative style
Coulomb force gravitational force spring force	friction force normal force

Table 1. Some examples of conservative and non-conservative forces

As we know, the difference between conservative and non-conservative forces lies in the dependence on the associated trajectory. Therefore, to overcome this difficulty, the concept of effort and energy theorem is introduced. This theorem reads

"The total effort exerted on an object is equal to the change in its kinetic energy"

Mathematically this theorem is formulated

$$\text{Wtotal} = \Delta Ek \quad (1)$$

The total effort in the left segment of equation (1) is the total effort exerted by both conservative and non-conservative forces.

On the one hand, the existence of effort by the conservative force presents the existence of potential energy which is defined as the effort to resist the conservative force, or mathematically it can be written as

$$W_{konservatif} = -\Delta Ep \quad (2)$$

Thus, the effort exerted by non-conservative forces is difficult to formulate the potential energy. Interestingly, if there is no non-conservative force, equation (1) will be reduced to the law of conservation of mechanical energy.

$$E_{k_1} + E_{p_1} = E_{k_2} + E_{p_2} \quad (3)$$

In this practicum, we will look at the graph patterns between position and velocityagainst time by conducting two experiments, namely free fall motion and motion on an inclined plane.

III. Preliminary Task

1. Look for other examples of conservative and non-conservative forces
2. Derive the potential energy for the weight of an object of mass *m* dropped at height *h* through equation (2).
3. Prove equation (3)

IV. Tools and Materials

1. *VTT console*
2. *chrono* sensor
3. set of free fall motion tools
4. inclined plane
5. ruler

V. Experiment Steps

1. Arrange the experiment circuit as shown in Figure [3]

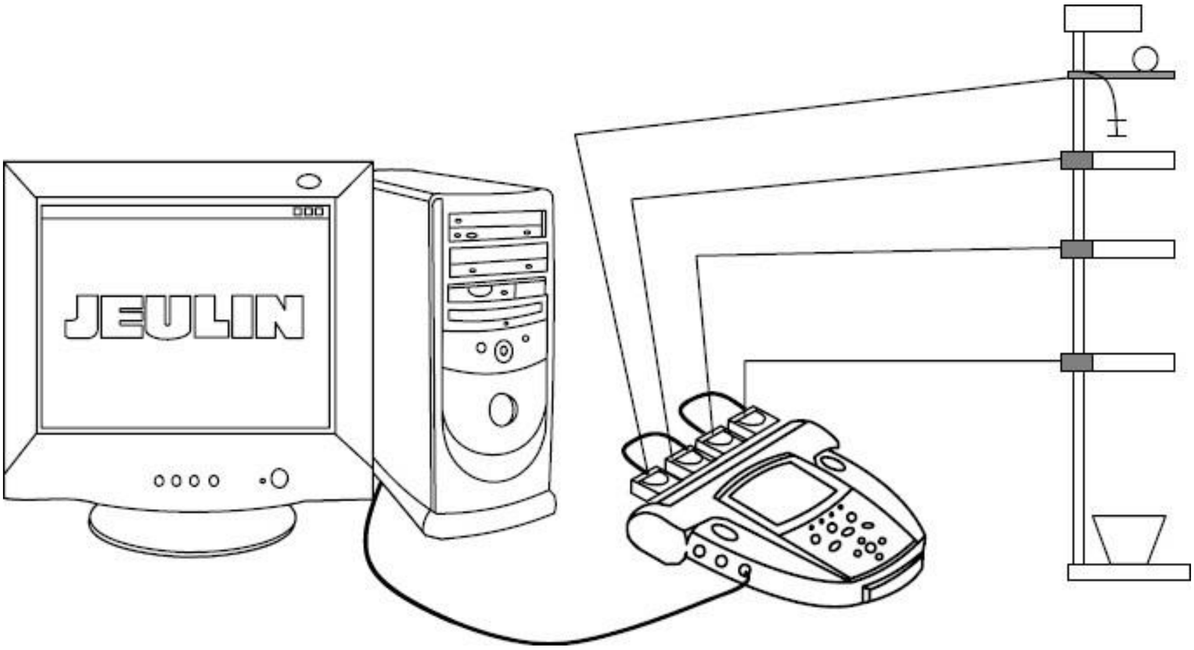


Figure 1. Free fall motion device circuit

Figure 2. Inclined plane motion device circuit

2. Set the sensor location in such a way (will be explained during the practicum)
3. Make a graph through software (will be explained during the practicum)
4. Compare theoretical calculations using the concept of Newton's second law with the concept of effort and energy theorem

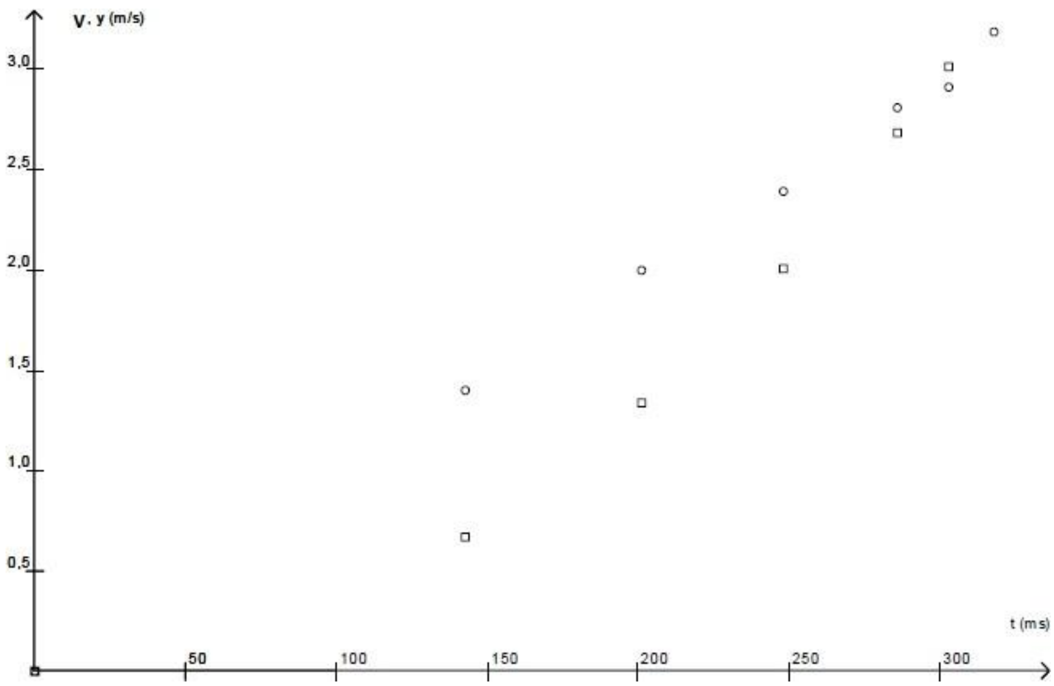


Illustration of the results of the free fall motion graph obtained

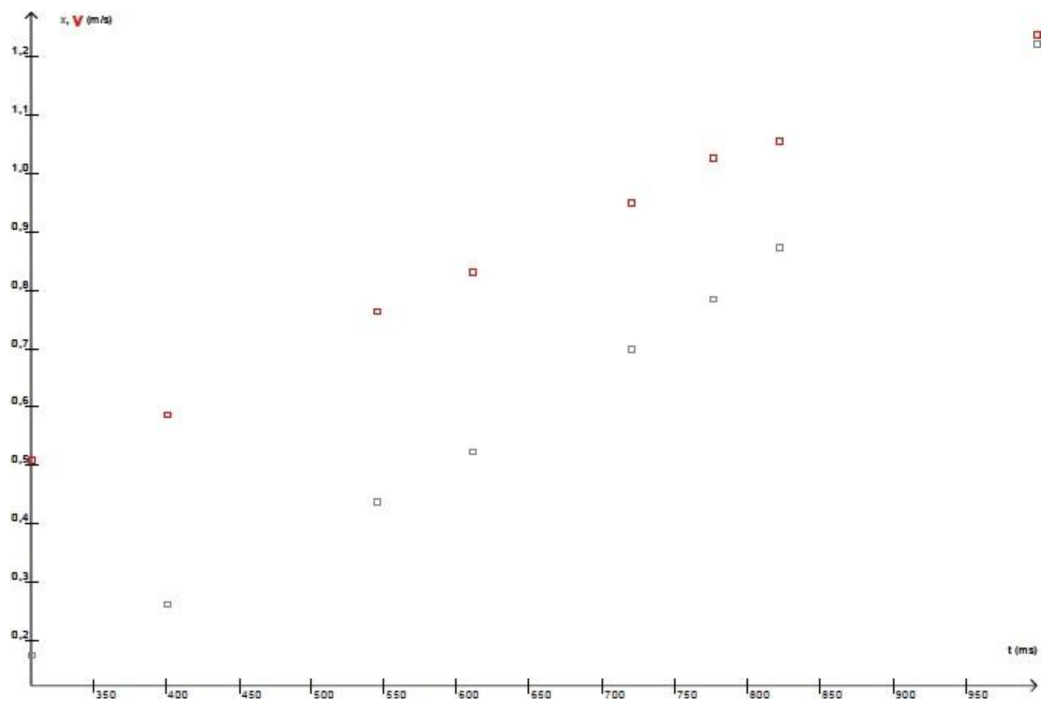


Illustration of the results of the graph of the motion of an object on an inclined plane obtained

5. Repeat the above experiment by changing the position of the sensor, then compare the results obtained with the previous results

VI. Final Project

1. Copy the recorded data and graph (will be explained during the practicum)
2. Create mathematical models for position and velocity
3. Analyze and conclude

Reference

1. Abdullah, M. (2007). Basic Physics Lecture Dictate I, Bandung: Bandung Institute of Technology.
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