



SIMPLE VISUALIZATION THEORY FOR INVESTIGATING THE MECHANICAL BEHAVIOR OF A NOVEL FIBER

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ABSTRACT

In this paper, a simple theoretical and visualized explanation of a novel fiber with their mechanical behaviors have been derived to investigate a novel fabricated fibers made by the changing a natural garbage structure. By solving a simple string theory consisted of two to three coupled differential equations, the internal frequencies (ω) and the fiber string constants (k) of two different fiber structures which have a uniform fiber structure and a not uniform fibers structure, respectively were obtained as follows: $\omega_{1,2} = \pm 7.312 \text{ Hz}$, for the value of $k_1 = k_2 = k = 0.46 \text{ kg/s}^2$, and $\omega_{1,2} = \pm 12.657 \text{ Hz}$, for the values of $k_1 = 0.5 \text{ kg/s}^2$, and $k_2 = 0.426 \text{ kg/s}^2$. While the ω and k of three different fiber structures in one fiber were found in the following values: $\omega_{1,2} = \pm 7.313 \text{ Hz}$, for $k_1 = 1.974 \text{ kg/s}^2$, $k_2 = 0.353 \text{ kg/s}^2$, and $k_3 = 0.989 \text{ kg/s}^2$, and $\omega_{1,2} = \pm 7.313 \text{ Hz}$, for the value of $k_1 = k_2 = k_3 = k = 0.69 \text{ kg/s}^2$, respectively. In addition, by incorporating a scientific mathematica 10.3 software, the visualizations from the coupled-two and coupled-three differential equations closely related to mechanical fiber behaviors produce the amplitude (A) ratio in those coupled equations.

Keywords: *Coupled differential equations; Exact solution; Fiber; Frequency (ω); Sinusoidal waves*

1. INTRODUCTION

In completing an advanced development of a new technology, an idea of novel breakthrough of theoretical creativity and an ability to make an excellent product as well as an accurate knowledge as a background to transform a useless thing to be the most attractive product or prototype with a multitasking application is really a must [1-6]. Nanotechnology as the applied nanoscience is a realization of two sides of an attractive scientific fields in science and engineering in this 21st century that make technology and engineering faster, smaller, sensitive and cheaper, so that all people in society with various levels of their social status can enjoy it all happily without doubt. In order to develop such incredible science, many contributed scientists with various background of life from generation to generation had been discovering God knowledge into practice and multidisciplinary applications in which such scientific knowledge cannot be wrong in any place and any time which is in contradictions with political and social sciences that are normally only true in certain society and nation or even just in a country or few connected countries. Many efforts conducted by a lot of wise men appeared obviously on their Jazher (true) book have been developed effectively and in such a way of smart styles to not only scientific society but also in ordinary people life. People from generation to generation have been investigating God who is exist among people but they have no idea who is this Guy, while the knowledge that they found cannot deny His creations among their heart, thought and desires [Ref. [7]: Josh. 10:13; Col. 1:26-29]. It should be noted that no matter how good and sophisticated man creations, they cannot be comparable with God laboratories existed everywhere on earth and in the giant universe with many complicated millions of galaxies structures connected one another viewed from earth skies, for example even a genuine modern nanochip that can be moved like a stylist car in human um blood cell or vain, cannot be comparable with God DNA (G, C, A, and T; [God Eternal Chip or created new spirit, Ref. [7]: Ezek. 11:19-20; Heb. 8:10; 10:16-18]) that controlled the human genetic codes inside human body. In addition, a man made nuclear fuel submarine cannot be comparable with God ocean structures that consisted of moving sea animals, a growing of many different types of coral reefs, a light matter interaction on it, and so forth. On the other hand, the way of thinking of human being identified as a ratio thinking cannot be comparable with the way of God thinking (called as a supraratio thinking plus ratio thinking). Here a ratio thinking is a part of supraratio thinking as well

as a supranatural power also involves natural power, and not the other way around [7, 9-11]. On the other hand, I could say that “the logic of the most sophisticated creations are not fully representing the creator logic.”

In this paper, we propose a very simple theory and its simulation to explain a mechanical behavior of a novel fiber which may be either uniform in its structure or not fully uniform. This simple idea was firstly presented or/ and introduced at the 1st international seminar of basic science at 17th birthday celebration of Faculty of Mathematics and Natural Sciences (FMIPA), Pattimura University (UNPATTI) on 3rd June of 2015 [8]. The detail of this simple theoretical model was based on a classical mechanics string theory which will be completely described in **Section II** of this paper. In addition, a simple simulation and its illustration was to describe how a novel fiber can be mechanically conducting their vibration. Further research works are being carried out in our research center of nanotechnology and innovative creation (**PPNRI-LEMLIT**) to develop this kind of smart simple device based on novel fibers technology.

2. THEORETICAL AND ILLUSTRATION MODEL OF A NOVEL FIBER

2.1. Basic Theoretical View of Mechanical Behaviors of a Fiber

The mechanical strengths [12] of these novel fibers are being investigated in our research center with a simple physical method which is based on the measurement of Young modulus (Y) and/or bulk modulus (B). Young modulus of a material normally happened when there is a force (F) applied in an area of a surface (A) of a material that makes it expands its length ($L+\Delta L$). Therefore, we can define Y as (**Ref. [13-14]**)

$$Y = (F/A) / (\Delta L/L). \quad (1)$$

While bulk modulus, B is measured based on the pressure change (Δp) applied in an area of a material that causes the volume change ($V+\Delta V$) defined as

$$B = -\Delta p / (\Delta V/V). \quad (2)$$

Figure 1 depicts the simple description technique to measure parameters Y and B , respectively.

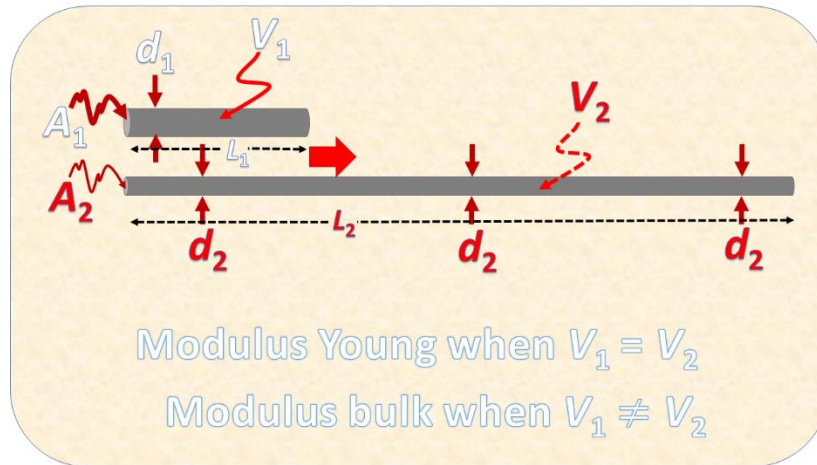


Figure 1. Experimental technique to measure both Young modulus and bulk modulus in a fiber.

The optical behaviors of these new fibers are also being under active research characterized with a simple technique described based on **Ref. [6]**. **Figure 2** shows a simple setup to measure the fiber elasticity constant (string constant, k). In the picture, the fiber behavior was like a string that can oscillate like a string with a constant k when the structure of the fiber is completely uniform or with few k_i constants in the length of fiber depending on the types of material structure in it.

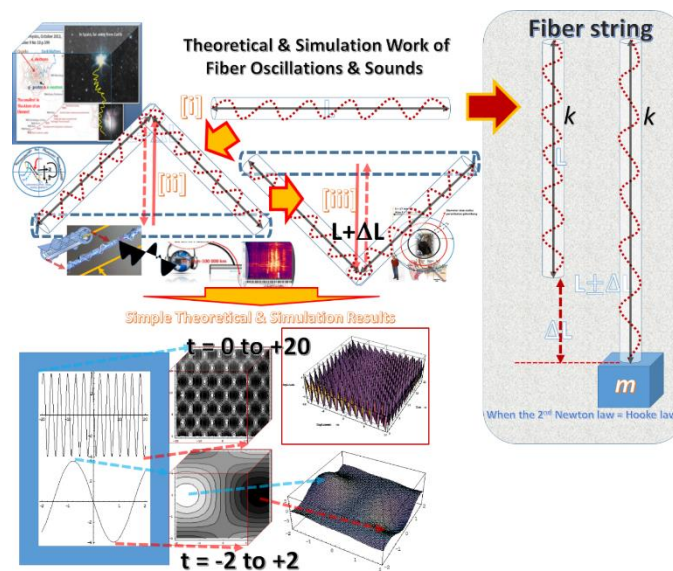


Figure 2. A cartoon description of a fiber that has theoretically a function like a string which can be able to elongate and vibrate [8].

2.2. Theoretical Coupled Differential Equations for a Fiber

In order to fully understand the very basic properties of some types of fiber oscillations, we introduce a simple theoretical study with simulation support on it as depicted in **Fig. 2** [8]. We obtained a kind of sound waves in the vibration types of the newly marine waste fibers as shown in **Fig. 3**. Furthermore, a simple prototype device is being developed to use these kind of fibers for integrated sensors such as **an integrated temperature-light-sound sensor** called as **ITLS-Sensor** as shown in **Fig. 4** [6].

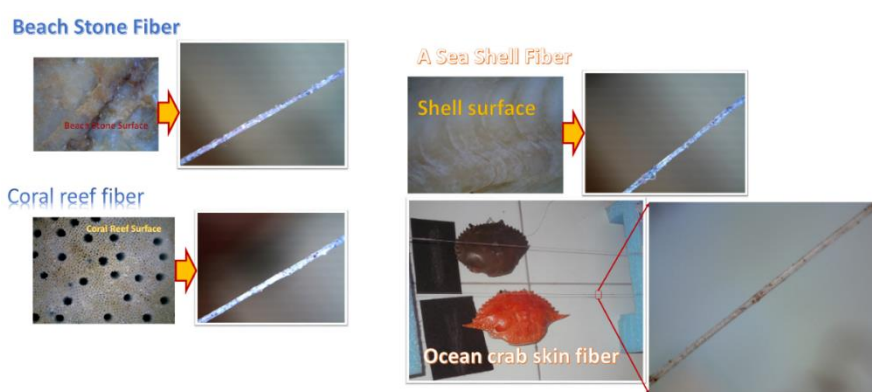


Figure 3. Some novel fibers fabricated from marine wasted materials [11] such as from a beach stone, a broken coral reef and sea animal shells (Courtesy of **H.I. Elim, et al.** and his team in **Lab. N4PN** and **PPNRI-LEMLIT** [15]).

Figure 3 shows that a behavior of a material can be fully changed when their structure was fully changed. Based on our former research [16], the optical properties of a complex molecule consisted of 2 to 3 atoms such as CaCO_3 existed in almost all ocean animals or coral reef structures, the behavior was significantly influenced by a kind of light wavelength matter interaction as well as temperature changes.

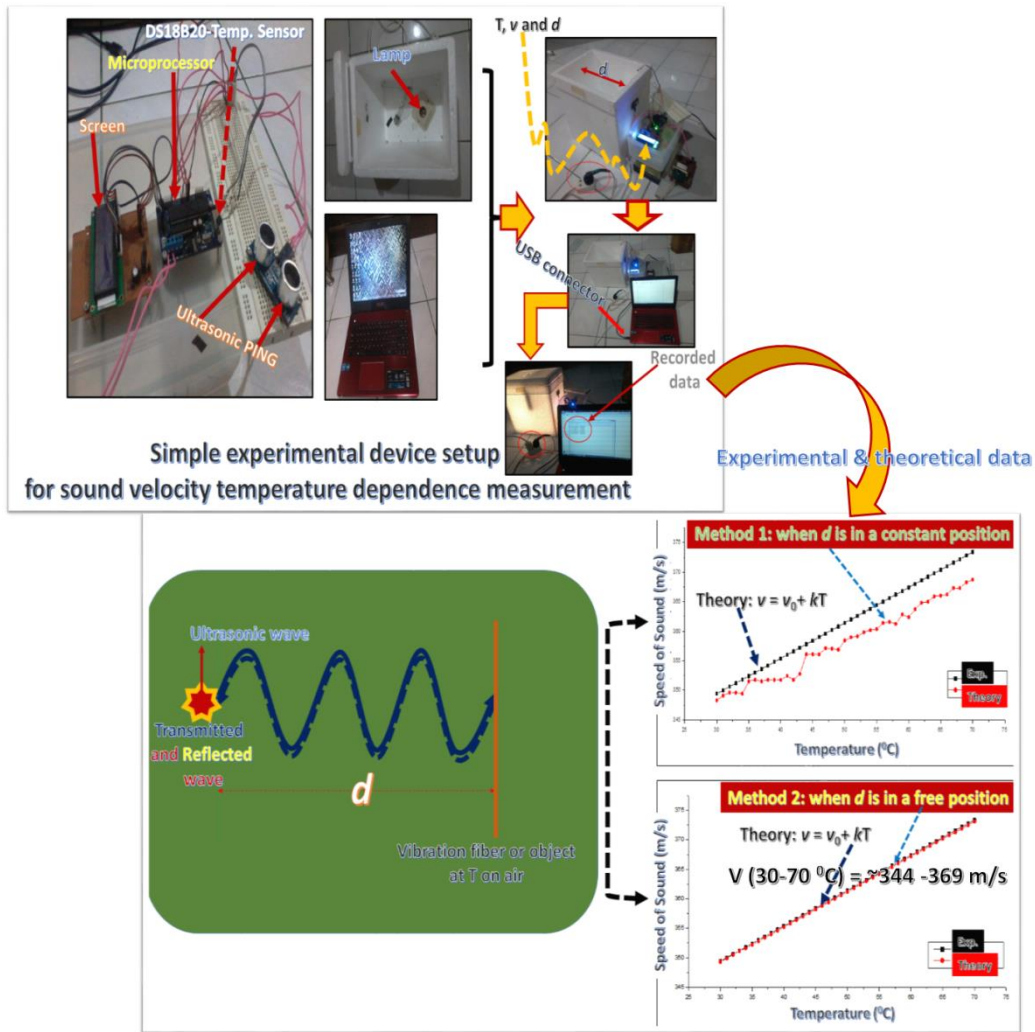


Figure 4. Simple device [6] fabricated to measure the sound velocity under the influence of room temperature $\sim 30 \text{ } ^\circ\text{C}$ up to $70 \text{ } ^\circ\text{C}$. The depicted picture describes a comparison of two types of methods using to measure the speed of sound under the change of temperature, T on air. The parameters v , v_0 , d , k , and T are the speed of sound, the speed of light when $T = 0 \text{ } ^\circ\text{C}$, the distant position of vibration fiber or object, a natural constant ($\text{m}/(\text{s } ^\circ\text{C})$) of the link between temperature and sound wave on air, and the temperature, respectively.

In order to explain our experimental data, we proposed a simple theoretical model as depicted in **Fig. 5**. In **Fig. 5(b)**, we consider our elastic fiber like a string with a string constant, k for a uniform fiber structure. While **Fig. 5(c)** and **Fig. 5(d)** are the illustration models for the fiber with 2 to 3 different structures, respectively.

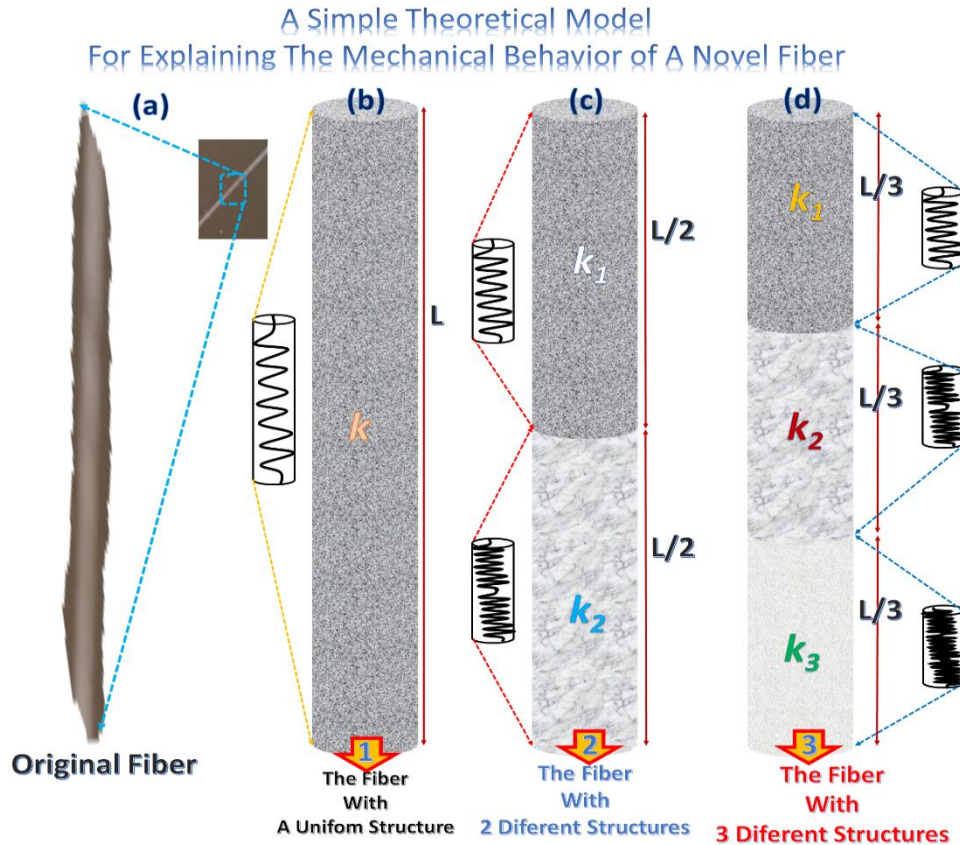


Figure 5. A simple theoretical model for explaining the mechanical behavior of a novel fiber.

In general by incorporating the classical mechanics rules derived by Newton and Hooke, respectively, one can obtain a simple harmonic oscillation equation in the case of **Fig. 5(b)** when it was treated by hanging a mass, m vertically on its bottom part as follows:

$$m \frac{d^2 y(t)}{dt^2} + k y(t) = 0, \quad (3)$$

where k is the string constant of the fiber.

Furthermore, in the case of **Fig. 5(c)** when it was treated by putting a mass m vertically on its bottom part, one can get the following couple differential equation:

$$\begin{aligned}
 -k_1 y_1(t) - k_2 [y_1(t) - y_2(t)] &= 0 \\
 -k_2 [y_2(t) - y_1(t)] &= m \frac{d^2 y_2(t)}{dt^2}, \quad (4)
 \end{aligned}$$

where k_1 and k_2 are the string constants for the top and bottom structures of the fiber.

In addition, the authors can obtain the coupled differential equations for **Fig. 5(d)** when the bottom part of fiber was connected with a mass, m as follows

$$\begin{aligned} -k_1 y_1(t) - k_2 [y_1(t) - y_2(t)] &= 0 \\ k_2 [y_1(t) - y_2(t)] - k_3 [y_2(t) - y_3(t)] &= 0 \\ k_3 [y_2(t) - y_3(t)] &= m \frac{d^2 y_3(t)}{dt^2}, \end{aligned} \quad (5)$$

where k_1 , k_2 , and k_3 are the string constants for three different structures in the fiber.

3. RESULTS AND DISCUSSION

3.1. The Exact Solutions of the Vibration Frequency in a Fiber

Based on the proposed two and three coupled differential equations (Eq.(4), and Eq. (5)) in a vertically simple harmonic oscillation with a periodic, T , phase, φ and inner frequency, ω of a fiber whose functions as a string under a burden of mass, m at the bottom of it, one can then simplify the equations into the following matrices, respectively:

$$\begin{bmatrix} -(k_1 + k_2) & k_2 \\ k_2 & -k_2 \end{bmatrix} \begin{bmatrix} y_1(t) \\ y_2(t) \end{bmatrix} = \begin{bmatrix} 0 \\ m \frac{d^2 y_2(t)}{dt^2} \end{bmatrix}, \quad (6)$$

and

$$\begin{bmatrix} -(k_1 + k_2) & k_2 & 0 \\ k_2 & -(k_2 + k_3) & k_3 \\ 0 & k_3 & -k_3 \end{bmatrix} \begin{bmatrix} y_1(t) \\ y_2(t) \\ y_3(t) \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ m \frac{d^2 y_3(t)}{dt^2} \end{bmatrix}. \quad (7)$$

The solution of Eq. (6) can be derived by introducing the physical meaning of such equation with a periodical wave function which indicates the vibration of a fiber as described in Fig. 5(c):

$$y_1(t) = A \sin(\omega t + \varphi), \text{ and} \quad (8a)$$

$$y_2(t) = B \sin(\omega t + \varphi), \quad (8b)$$

where A and B are the amplitudes for each wave function of $y_1(t)$, and $y_2(t)$, respectively.

By inserting Eq. (8a) and Eq. (8b) into Eq.(6), we obtain

$$\begin{bmatrix} -(k_1 + k_2) & k_2 \\ k_2 & -k_2 \end{bmatrix} \begin{bmatrix} A \sin(\omega t + \varphi) \\ B \sin(\omega t + \varphi) \end{bmatrix} = \begin{bmatrix} 0 \\ m \frac{d^2}{dt^2} B \sin(\omega t + \varphi) \end{bmatrix},$$

or

$$-(k_1 + k_2)A \sin(\omega t + \varphi) + k_2 B \sin(\omega t + \varphi) = 0,$$

$$k_2 A \sin(\omega t + \varphi) - k_2 B \sin(\omega t + \varphi) = -m B \omega^2 \sin(\omega t + \varphi),$$

or such equation is then simplified by deviding it with $\sin(\omega t + \varphi)$ as folows

$$-(k_1 + k_2)A + k_2 B = 0,$$

$$k_2 A + (m\omega^2 - k_2)B = 0. \quad (9)$$

This Eq. (9) can then be written in a mattix form as folow

$$\begin{bmatrix} -(k_1 + k_2) & k_2 \\ k_2 & (m\omega^2 - k_2) \end{bmatrix} \begin{bmatrix} A \\ B \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \quad (10)$$

with the exact solution of frequencies, $\omega_{1,2}$ related to the values of string constants, k_1 and k_2 are extracted from the following short solution of Eq. (10):

$$-(k_1 + k_2)(m\omega^2 - k_2) - k_2^2 = 0,$$

or

$$-(k_1 + k_2)m(\omega^2) + k_1 k_2 = 0,$$

or

$$\omega_{1,2} = \pm \left(\frac{1}{\sqrt{m}} \right) \frac{\sqrt{(k_1 + k_2)k_1 k_2}}{(k_1 + k_2)},$$

or

$$\omega_{1,2} = \pm \left(\frac{1}{\sqrt{m}} \right) \sqrt{\frac{k_1 k_2}{k_1 + k_2}}. \quad (11)$$

In Eq. (11), we find that the total fiber constant (k_t) with two different structures connected one another vertically with a mass, m at their bottom is

$$k_t = \frac{k_1 k_2}{k_1 + k_2}. \quad (12)$$

Moreover, the $\omega_{1,2}$ in Eq. (11) are actually the only possibility of the exact solution if the vibration of structure 1 and structure 2 in a fiber as depicted in Fig. 5(b) is independent one another. In fact, when the whole fiber is vibrating with a sinusoidal wave function, the two different structures in the fiber will influence one another. Therefore, we propose another solution to find out the internal vibration frequency in each structure (ω_1 and ω_2) due to interconnection of the two different structures as follows

$$y_1(t) = A_1 \sin(\omega_1 t + \varphi_1) + A_2 \sin(\omega_2 t + \varphi_2), \quad (13a)$$

and

$$y_2(t) = B_1 \sin(\omega_1 t + \varphi_1) + B_2 \sin(\omega_2 t + \varphi_2). \quad (13b)$$

By substituting Eqs. (13a) and (13b) into Eq. (6), we then obtain

$$\begin{aligned} & \begin{bmatrix} -(k_1 + k_2) & k_2 \\ k_2 & -k_2 \end{bmatrix} \begin{bmatrix} A_1 \sin(\omega_1 t + \varphi_1) + A_2 \sin(\omega_2 t + \varphi_2) \\ B_1 \sin(\omega_1 t + \varphi_1) + B_2 \sin(\omega_2 t + \varphi_2) \end{bmatrix} \\ &= \begin{bmatrix} 0 \\ m \frac{d^2}{dt^2} \{B_1 \sin(\omega_1 t + \varphi_1) + B_2 \sin(\omega_2 t + \varphi_2)\} \end{bmatrix}, \end{aligned}$$

and then

$$\begin{aligned} & \begin{bmatrix} -(k_1 + k_2) & k_2 \\ k_2 & -k_2 \end{bmatrix} \begin{bmatrix} A_1 \sin(\omega_1 t + \varphi_1) + A_2 \sin(\omega_2 t + \varphi_2) \\ B_1 \sin(\omega_1 t + \varphi_1) + B_2 \sin(\omega_2 t + \varphi_2) \end{bmatrix} \\ &= \begin{bmatrix} 0 \\ m \{-\omega_1^2 B_1 \sin(\omega_1 t + \varphi_1) - \omega_1^2 B_2 \sin(\omega_2 t + \varphi_2)\} \end{bmatrix}. \quad (14) \end{aligned}$$

The solution of the amplitudes A_1 , B_1 , A_2 , and B_2 embedded in Eq. (14) can be extracted using a relationship between Eq. (9), and Eq. (14) in the following short cut calculation:

$$\begin{aligned} -(k_1 + k_2)A + k_2 B = 0 &\Rightarrow \frac{A}{B} = \frac{k_2}{k_1 + k_2} \\ k_2 A + (m\omega^2 - k_2)B = 0 &\Rightarrow \frac{A}{B} = \frac{-(m\omega^2 - k_2)}{k_2}, \end{aligned}$$

where there are A_1 , B_1 , A_2 , and B_2 , as well as ω_1 and ω_1 inside these two equations here. Therefore, one can solve it shortly by introducing a parameter, λ as the following simple mathematics form:

$$\frac{A_1}{B_1} = \frac{-(m\omega_1^2 - k_2)}{k_2} = \frac{(k_2)}{(k_1 + k_2)} = \frac{1}{\lambda_1} \Rightarrow A_1\lambda_1 = B_1,$$

or

$$\lambda_1 = \frac{(k_1 + k_2)}{(k_2)} \Rightarrow A_1 \left(\frac{(k_1 + k_2)}{(k_2)} \right) = B_1, \quad (15a)$$

and

$$\frac{A_2}{B_2} = \frac{-(m\omega_2^2 - k_2)}{k_2} = \frac{(k_2)}{(k_1 + k_2)} = \frac{1}{\lambda_2} \Rightarrow A_2\lambda_2 = B_2,$$

or

$$\lambda_2 = \frac{(k_1 + k_2)}{(k_2)} = \lambda_1 = \lambda \Rightarrow A_2 \left(\frac{(k_1 + k_2)}{(k_2)} \right) = B_2; A_2\lambda = B_2. \quad (15b)$$

By substituting Eq. (15a) and Eq. (15b) into Eq. (13a), and Eq. (13b), we get

$$y_1(t) = A_1 \sin(\omega_1 t + \varphi_1) + A_2 \sin(\omega_2 t + \varphi_2), \text{ and} \quad (16a)$$

$$y_2(t) = \lambda \{A_1 \sin(\omega_1 t + \varphi_1) + A_2 \sin(\omega_2 t + \varphi_2)\} = \lambda y_1(t). \quad (16b)$$

Based on Eqs. (16a) and (16b), the vibration wave functions ($y_1(t)$ and $y_2(t)$) of a fiber with two different structures on the top and bottom parts of the fiber shows just a different in their eigenvalue of λ that directly contributes to the amplitude of the fiber when it is vibrating. The indicator of our calculation in Eqs. (15) shows that $\lambda_1 = \lambda_2 = \lambda$ which means that there are no different of internal frequency in such two different structures fibers or $\omega_1 = \omega_2$. While as shown in Eq. (11), this inner frequency, ω has only two propagation directions which mean that the amount frequency is the same but the only change is its vertically moving direction either up or down.

Figure 6 shows the wave functions of two different structures fiber in which the bottom structure contributes to the enhancement of twice amplitude larger than that from the top part of fiber.

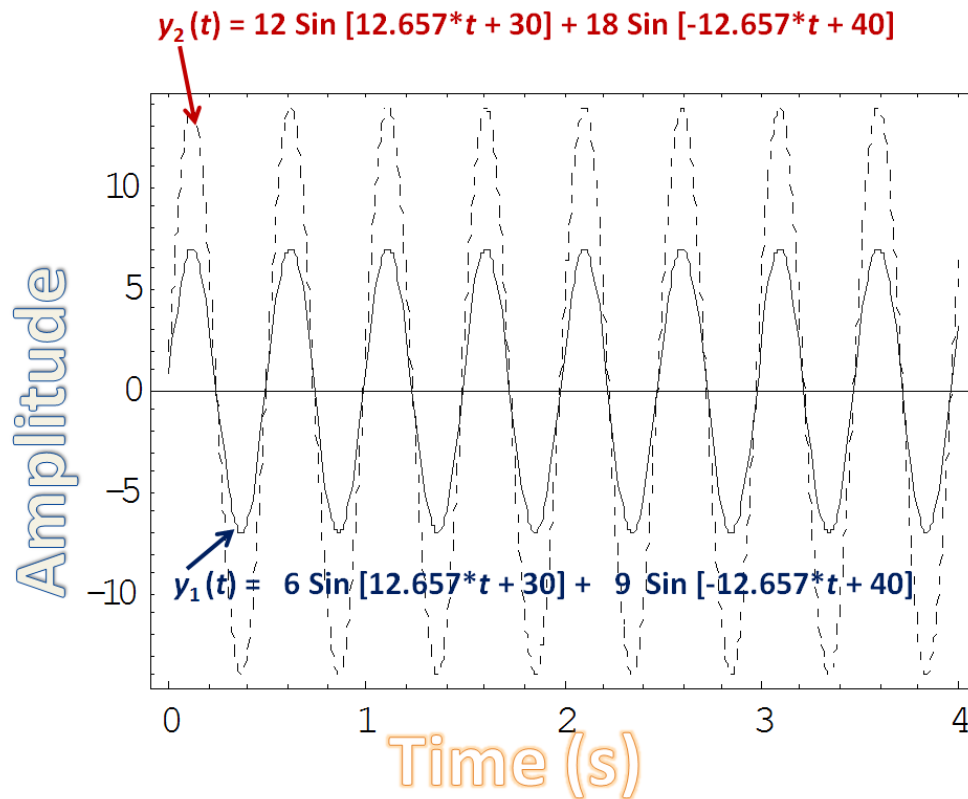


Figure 6. An example of wave functions when a fiber consisted of two different structures on top and the bottom of it when a mass, m was hanging at the bottom of it.

Furthermore, by using the similar way of solution in **Eq. (5)** associated with **Fig. 5(d)**, one can derive the exact solution of Eq.(7) as follows

$$\begin{bmatrix} -(k_1 + k_2) & k_2 & 0 \\ k_2 & -(k_2 + k_3) & k_3 \\ 0 & k_3 & -k_3 \end{bmatrix} \begin{bmatrix} A \sin(\omega_1 t + \varphi_1) \\ B \sin(\omega_2 t + \varphi_2) \\ C \sin(\omega_3 t + \varphi_3) \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ m \frac{d^2 y_3(t)}{dt^2} \end{bmatrix}, \quad (17)$$

where one supposes the solution of each part of the fiber's structures has the vibration function as follows $y_1(t) = A \sin(\omega_1 t + \varphi_1)$, $y_2(t) = B \sin(\omega_2 t + \varphi_2)$, and $y_3(t) = C \sin(\omega_3 t + \varphi_3)$. The solution of Eq.(17) can be simplified as the following form:

$$\begin{aligned} & (-(k_1 + k_2))A \sin(\omega_1 t + \varphi_1) + (k_2)B \sin(\omega_2 t + \varphi_2) = 0 \\ & (k_2)A \sin(\omega_1 t + \varphi_1) + (-(k_2 + k_3))B \sin(\omega_2 t + \varphi_2) + (k_3)C \sin(\omega_3 t + \varphi_3) = 0 \\ & (k_3)B \sin(\omega_2 t + \varphi_2) + C [m \omega_3^2 - (k_3)] \sin(\omega_3 t + \varphi_3) = 0 \end{aligned}$$

or

$$\begin{bmatrix} -(k_1 + k_2) & k_2 & 0 \\ k_2 & -(k_2 + k_3) & k_3 \\ 0 & k_3 & m \omega_3^2 - (k_3) \end{bmatrix} \begin{bmatrix} A \sin(\omega_1 t + \varphi_1) \\ B \sin(\omega_2 t + \varphi_2) \\ C \sin(\omega_3 t + \varphi_3) \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad (18)$$

meaning the front matrix should be equal to zero as follow

$$\begin{bmatrix} -(k_1 + k_2) & k_2 & 0 \\ k_2 & -(k_2 + k_3) & k_3 \\ 0 & k_3 & m \omega_3^2 - (k_3) \end{bmatrix} = 0. \quad (19)$$

By solving Eq. (19), we obtain

$$\omega_3 = \pm \sqrt{\frac{k_1 k_2 k_3}{m(k_1 k_2 + k_2 k_3 + k_1 k_3)}}. \quad (20)$$

If the frequency $\omega_3 = \omega_2 = \omega_1 = \omega$ which means that the quality fiber just depended on its structure parts connected to its k_1, k_2 and k_3 , one can then get the only two possibilities of angular frequency of the fiber in two directions (up or down paths) with its amount is as large as

$$\omega_{1,2} = \pm \left(\frac{1}{\sqrt{m}} \right) \sqrt{\frac{k_1 k_2 k_3}{(k_1 k_2 + k_2 k_3 + k_1 k_3)}}. \quad (21)$$

Eq. (21) shows that the total fiber constant (k_t) with three different structures connected one another vertically with a mass, m at their bottom is

$$k_t = \frac{k_1 k_2 k_3}{(k_1 k_2 + k_2 k_3 + k_1 k_3)}. \quad (22)$$

3.2. The Applications of Theory in Checking Experimental Data

In order to prove that our theory is true or available in experimental evident, we now try to calculate the observation data of few novel fibers fabricated by some of our graduated B.Sc research students in PPNRI-LEMLIT or Lab. N4PN of Physics Department, UNPATTI, Ambon, Indonesia.

For example, based on our novel fiber fabricated using river snail skin with $k = 0.46 \text{ kg/s}^2$ [17], the uniform novel fiber indicates that Eq.(11) can extract the angular frequency value, $\omega_{1,2} = \pm 7.312 \text{ Hz}$, for the value of $k_1 = k_2 = k = 0.46 \text{ kg/s}^2$. While the value of

frequency is $\omega_{1,2} = \pm 12.657 \text{ Hz}$, if there are 2 different structures in the fiber, for instance, $k_1 = 0.5 \text{ kg/s}^2$, and $k_2 = 0.426 \text{ kg/s}^2$. On the other hand, if we supposed the novel fiber had 3 different structures, then the values of ω and k of such three different fiber structures in one fiber were obtained in the following values: $\omega_{1,2} = \pm 7.313 \text{ Hz}$, for $k_1 = 1.974 \text{ kg/s}^2$, $k_2 = 0.353 \text{ kg/s}^2$, and $k_3 = 0.989 \text{ kg/s}^2$, and $\omega_{1,2} = \pm 7.313 \text{ Hz}$, for the uniform fiber with the value of $k_1 = k_2 = k_3 = k = 0.69 \text{ kg/s}^2$, respectively. In addition, by incorporating a scientific *mathematica* version 5.0/ 10.3 software, the visualizations from the coupled-two and coupled-three differential equations closely related to mechanical fiber behavior produce the amplitude (A) ratio in those coupled equations. **Figure 7** shows the simulation picture of a novel fiber consisted of three different structures with the same phase of $\varphi_1 = 30$. Another graph (with red line) shows a comparison with the former vibration of $y_1(t)$ with a bit shift of frequency from 7.312 to 7.313 and $\varphi_2 = 20$. We can see that the amplitude of a wave vibration depends significantly on the spring constant of a fiber: the larger the k , the larger the amplitude. On the other hand, the position of the wave will be sifted horizontally when the phase is shifted.

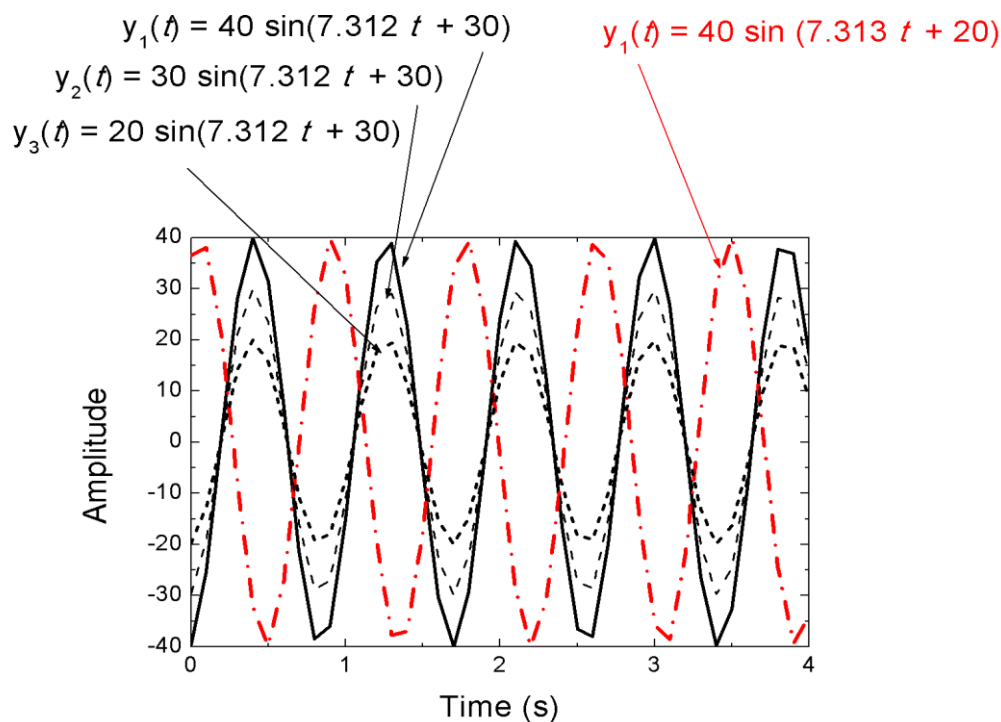


Figure 7. The vibration wave of a novel fiber with three different structures on it.

4. CONCLUSION

In summary, we have already shown that a very simple theoretical explanation and its simulation were capable enough to understand the mechanical behaviors of a novel fiber fabricated using even many types of garbage both in nature and human products. The exact solutions of internal frequencies (ω) or angular frequency of a fiber with two to three different structures can be found by solving the related two to three coupled differential equations. Moreover, we suggest that this theory can be developed with more investigation with a complex structure of a novel fiber.

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