PREMPEH COLLEGE
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Our Ref: .....

Your Ref: .....

Date: 19/10/23

The Managing Director,
Primetime Limited

PROTEST

We, the coordinators of the Prempeh College NSMQ Team and Old Boys, acting for and on behalf of Prempeh College, write to register our displeasure at the events leading to the conclusion of the 2nd Semifinal contest of this year's NSMQ competition held at the Saarah Mensah Auditorium of KNUST Kumasi today, 19th day of October 2023 between 1330hrs and 1700hrs GMT, among Prempeh College, Pope Johns Snr High and Opoku Ware School.

Before going into the gravamen of the matter, we wish to highlight a few things. Prempeh College has since the inception of this competition been a worthy competitor and has been a mainstay of this contest which is evidenced by the number of trophies won by the school since the competition's inception and has the distinction of being the first school to win the coveted trophy in 1993. Over the years we have watched the brand grow and expand to attract keen interest from diverse strata of society. We have always attached seriousness to this endeavour and have been gracious in both victory and defeat. We have however noticed that over time the competition is taking on a computation that does not auger well for the future of the contest. Over the years we have had to endure a few missteps and miscalculations on the part of the organizers which have been inimical to our interest. We are however constrained at this time to protest and draw your attention to the glaring injustice meted to us and to seek your urgent intervention to right an obvious injustice and repair a wrong.
At the said contest during the last round (Round 5), a particular riddle was posed to the teams with the following clues:

1. I am a physical principle
2. Even though there is no theoretical basis for me, I am an experimentally confirmed principle

3. I operate across many domains of physics including mechanics, electromagnetism, and even quantum mechanics
4. According to me, the whole is equal to the sum of the parts
5. You call on me whenever you determine the electric field or the scalar potential at a point due to a collection of stationary charges
   So, who am I?

The Prempeh College contestant gave the answer as the principle of superposition, but the consultant argued that the answer was the principle of linear superposition. He claims there exists other types of superposition like exponential superposition hence the answer the student gave is incorrect.

Customarily, competing schools are allowed to protest if decisions taken do not go their way. During such protests, protesting schools are allowed to air their grievances for the consultants to assess and make a judgment on them.

Opoku Ware School, during this same competition, went down this same tangent and got themselves three (3) extra points after the first round.

However, upon protesting, the consulting Physics Professor present, disallowed the answer given by the contestant from Prempeh College arguing that there could also be the existence of the Principle of Exponential Superposition.

We argue that the student was correct based on the following points:
1. There are several sources that show that the principle of superposition when used applies to only linear systems. When applied in the broadest sense the principle of superposition is also known as the principle of linear superposition. See the image of Freedman Physics attached below.
2. There is no clue in the riddle that restricts the answer to the principle of linear superposition.
3. The application of the principle of superposition to electrical circuits would be the only point that nullifies it being the correct answer to the riddle. The third clue did not include electrical circuits.
4. What's the principle of superposition as defined in physics?
How different is its definition as given in literature from the principle of linear superposition?
Which clue in the riddle defies it?

Here are attachments showing that the two names can be used interchangeably to refer to the same principle.

https://www.britannica.com/science/principle-of-superposition-wave-motion
https://phys.libretexts.org/Bookshelves/University_Physics/Book%3A_Physics_%28Boundless%29/17%3A_Electric_Charge_and_Field/17.3%3A_Coulombs_Law

charged particles in a semiconductor electronic device, you have to know the detailed nature of the electric field acting on the charges.

The Superposition of Electric Fields

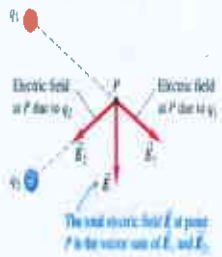
To find the field caused by a charge distribution, we imagine the distribution to be made up of many point charges $q_1, q_2, q_3, \ldots$. (This is actually quite a realistic description, since we have seen that charge is carried by electrons and protons that are so small as to be almost pointlike.) At any given point P, each point charge produces its own electric field $\vec{E}_1, \vec{E}_2, \vec{E}_3, \ldots$, so a test charge q_0 placed at P experiences a force $\vec{F}_1 = q_0\vec{E}_1$ from charge q_1, a force $\vec{F}_2 = q_0\vec{E}_2$ from charge q_2, and so on. From the principle of superposition of forces discussed in Section 21.3, the *total* force $\vec{F}_0$ that the charge distribution exerts on q_0 is the vector sum of these individual forces:

$$\vec{F}_0 = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots = q_0\vec{E}_1 + q_0\vec{E}_2 + q_0\vec{E}_3 + \cdots$$

The combined effect of all the charges in the distribution is described by the *total* electric field $\vec{E}$ at point P. From the definition of electric field, Eq. (21.3), this is

$$\vec{E} = \frac{\vec{F}_0}{q_0} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \cdots$$

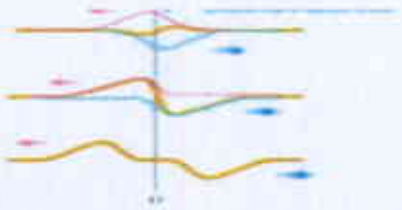
21.21 Illustrating the principle of superposition of electric fields.



The total electric field at P is the vector sum of the fields at P due to each point charge in the charge distribution (Fig. 21.21). This is the **principle of superposition of electric fields.**

When charge is distributed along a line, over a surface, or through a volume, a few additional terms are useful. For a line charge distribution (such as a long, thin, charged plastic rod), we use λ (the Greek letter lambda) to represent the **linear charge density** (charge per unit length, measured in C/m). When charge is distributed over a surface (such as the surface of the imaging drum of a laser printer), we use σ (sigma) to represent the **surface charge density** (charge per unit area, measured in C/m^2). And when charge is distributed through a volume, we use ρ (rho) to represent the **volume charge density** (charge per unit volume, C/m^3).

Some of the calculations in the following examples may look fairly intricate



is always zero. For this to occur, the reflected pulse must be inverted relative to the incident pulse.

Figure 15.21 shows two pulses with the same shape, traveling in opposite directions but are inverted relative to each other. The displacement at point O in the middle of the figure is not zero, but the slope of the string at this point is always zero. According to Eq. (15.20), this corresponds to the absence of any transverse force at this point. In this case the motion of the left half of the string would be the same as if we cut the string at point O and attached the end to a frictionless sliding ring (Fig. 15.19b) that maintains tension without exerting any transverse force. In other words, this situation corresponds to reflection of a pulse at a free end of a string at point O. In this case the reflected pulse is not inverted.

The Principle of Superposition

Combining the displacements of the separate pulses at each point to obtain the actual displacement is an example of the principle of superposition: When two

waves overlap, the actual displacement of any point on the string at any time is obtained by adding the displacement the point would have if only the first wave were present and the displacement it would have if only the second wave were present. In other words, the wave function $y(x, t)$ that describes the resulting motion in this situation is obtained by adding the two wave functions for the two separate waves:

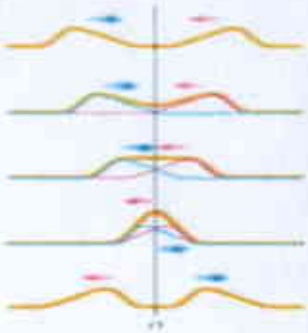
$$y(x,t) = y_1(x,t) + y_2(x,t) \qquad \text{(principle of superposition)} \quad (15.27)$$

Mathematically, this additive property of wave functions follows from the form of the wave equation, Eq. (15.12) or (15.13), which every physically possible wave function must satisfy. Specifically, the wave equation is *linear*; that is, it contains the function $y(x, t)$ only to the first power (there are no terms involving $y(x, t)^2$, $y(x, t)^{1/2}$, etc.). As a result, if any two functions $y_1(x, t)$ and $y_2(x, t)$ satisfy the wave equation separately, then $y_1(x, t) + y_2(x, t)$ also satisfies it and is therefore a physically possible motion. Because the principle depends on the linearity of the wave equation and the corresponding linear-combination property of its solutions, it is also called the *principle of linear superposition*. For some physical systems, such as a medium that does not obey Hooke's law, the wave equation is *not* linear, this principle does not hold for such systems.

The principle of superposition is of central importance in all types of waves. When a friend talks to you while you are listening to music, you can distinguish the sound of speech and the sound of music from each other. This is precisely because the total sound wave reaching your ears is the algebraic sum of the wave produced by your friend's voice and the wave produced by the speakers of your stereo. If two sound waves did not combine in this simple linear way, the sound you would hear in this situation would be a hopeless jumble. Superposition also applies to electromagnetic waves (such as light) and many other types of waves.

Test Your Understanding of Section 15.6 Figure 15.22 shows two wave pulses with different shapes traveling in different directions along a string. Make a series of sketches like Fig. 15.21 showing the shape of the string as the two pulses approach, overlap, and then pass each other.

15.21 Overlap of two wave pulses with equal and opposite displacements. Time increases from top to bottom. Compare to Fig. 15.20.



15.22 Two wave pulses with different shapes.

15.7 Standing Waves on a String

We have talked about the reflection of a wave pulse on a string when it arrives at a boundary point (either a fixed end or a free end). Now let's look at what happens when a sinusoidal wave is reflected by a fixed end of a string. We'll again approach the problem by considering the superposition of two waves propagating through the string, one representing the original or incident wave and the other representing the wave reflected at the fixed end.

Figure 15.23 shows a string that is fixed at its left end. Its right end is moved up and down in simple harmonic motion to produce a wave that travels to the

present. In other words, the wave function $y(x, t)$ that describes the resulting motion in this situation is obtained by *adding* the two wave functions for the two separate waves:

$$y(x, t) = y_1(x, t) + y_2(x, t) \qquad \text{(principle of superposition)} \quad (15.27)$$

Mathematically, this additive property of wave functions follows from the form of the wave equation, Eq. (15.12) or (15.18), which every physically possible wave function must satisfy. Specifically, the wave equation is *linear*; that is, it contains the function $y(x, t)$ only to the first power (there are no terms involving $y(x, t)^2$, $y(x, t)^{1/2}$, etc.). As a result, if any two functions $y_1(x, t)$ and $y_2(x, t)$ satisfy the wave equation separately, their sum $y_1(x, t) + y_2(x, t)$ also satisfies it and is therefore a physically possible motion. Because this principle depends on the linearity of the wave equation and the corresponding linear-combination property of its solutions, it is also called the *principle of linear superposition*. For some physical systems, such as a medium that does not obey Hooke's law, the wave equation is *not* linear; this principle does not hold for such systems.

The principle of superposition is of central importance in all types of waves. When a friend talks to you while you are listening to music, you can distinguish the sound of speech and the sound of music from each other. This is precisely because the total sound wave reaching your ears is the algebraic sum of the wave produced by your friend's voice and the wave produced by the speakers of your stereo. If two sound waves did not combine in this simple lin-

tion. Compare to Fig. 15.26.

23.2 THE PRINCIPLE OF SUPERPOSITION

The principle of superposition states that whenever two waves are travelling in the same region the total displacement at any point is equal to the vector sum of their individual displacements at that point.

The principle has been applied in producing Fig. 23.3, which represents two waves (A and B) of different amplitudes and frequencies being propagated along a single string.

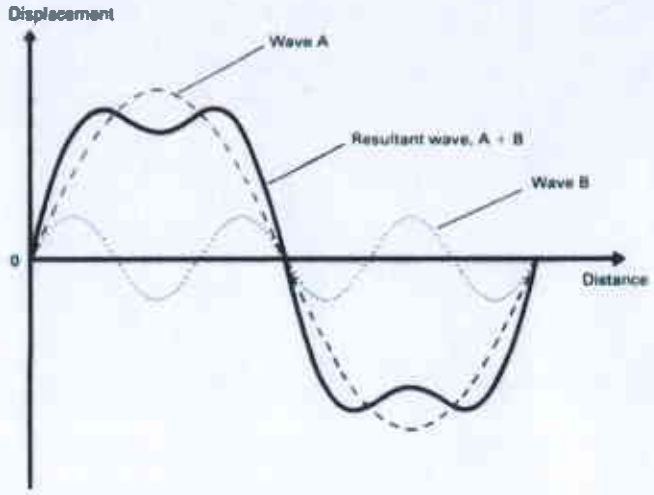


Fig. 23.3
To illustrate the principle of superposition

Whenever two waves are not travelling along the same line but merely cross at some point, they each emerge from the crossing point in the same form as they entered it. The principle of superposition applies at the point where they cross.

The phenomena of interference, diffraction, beats and stationary waves are consequences of the superposition of waves.

3.2 SUPERPOSITION OF WAVES

In Section 2.3 we studied the basic parameters of a wave. One or more of these parameters (except the frequency and coherence time which are the characteristics of the emission process) will undergo a change when a wave encounters either matter—leading to phenomena such as scattering or absorption—or a field—leading to effects such as electrooptic effect or acoustooptic effect. Of interest to us here is what happens to a (light) wave when it encounters another (light) wave. What is the result of superposition of two waves?

The answer is implicit in the statement that Eq. 2.4 is the solution of Eq. 2.1, that is, if y_1 and y_2 are solutions of Eq. 2.1, then $y = y_1 + y_2$ is also a solution. The superposition principle thus states that the *resultant disturbance is the algebraic sum of the disturbances of the separate constituent waves*. It should be noted here that the superposition principle is a consequence of the linearity of the wave equation (see Ex. 3.1). In case of high amplitude waves, there is a departure from linearity and the superposition principle is not applicable. Example 3.2 illustrates how the superposition principle can be applied in two special cases.

EXAMPLE 3.1
Superposition principle as a consequence of linearity of wave equation

Suppose the wave equation (see Eq. 2.1) is changed to $\partial^2 y/\partial x^2 = (1/v^2)(\partial y/\partial t)^2$. Will the superposition principle still hold?

From the foregoing, it is apparent that not only was the consultant wrong it was clear that he exercised his discretion without recourse to the cardinal principles of the exercise of discretion. Be that as it may, this is a science contest and not social science, and thus responses to inquiries do not lend themselves to arguments since it is a matter of proof and not opinion.

We are therefore in this vein requesting with immediate effect the rectification of the error for Prempeh College to be duly awarded what they've earned and for your esteemed organization to publish without equivocation the rectification and the restitution so done.

This will not only safeguard the integrity of the contest but will remove all perceptions of bias and perceived agenda to disadvantage certain schools in favour of others.

We do not take this lightly and wish to point out that we are ready and willing to pursue this matter to its logical conclusion including but not limited to recourse to judicial processes.

Yours faithfully,

P.B. Damoah

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Mr. Paul Damoah
(Quiz Coordinator)

.....
Snr. Dr. Ebenezer Owusu Wireko
(Old Boys' Representative)

Cc: Ghana Education Service
Ministry of Education
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