Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science (Second Year)

Subject: Physics

Paper Code: PYC103

Paper Title: Waves and Oscillations and Electronics-Section I

Unit: 1

Module Name: Kinetic and Potential Energy

Module No: 03

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Transcript: Kinetic and Potential energy

Slide 1:

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Slide 2:

Hi there! This is Abigail De Souza

Slide 3:

Welcome to this Physics lecture on the course titled Waves & Oscillations and Electronics. This lecture is from Section-I of the course from the unit: Waves and Oscillation.

Slide 4:

The topics included in this lecture are:

Kinetic energy

Potential energy

Total energy of oscillator.

Slide 5: learning outcomes:

Upon completion of this module one will be able to:

Determine the kinetic and potential and total energy of a Simple Harmonic Oscillator.

Slide 6:

Before we start, let us familiarise ourselves with the idea of kinetic energy and potential energy associated with an oscillator.

- For a Simple Harmonic Oscillator, Kinetic energy is associated with the motion of the oscillator, whereas the potential energy is associated with the restoring force.
- While performing S.H.M an oscillator constantly performs a transfer of energy between Kinetic energy and potential energy and vice versa.
- While oscillating the oscillator develops maximum potential energy when the oscillator is at maximum displacement from mean position.
- This potential energy drives the oscillator back to its mean position while increasing its kinetic energy which maximises at the mean position.

Slide 7: For a Simple Harmonic Oscillator (SHO), Energy is transformed between kinetic and potential energy, but the total mechanical energy E remains constant.

In a spring and mass system, whenever a spring is stretched/compressed, it develops PE in it. Upon releasing this stretched spring, this potential energy gets converted into kinetic energy and the spring moves. This movement further may stretch or compress the spring, and while doing so the kinetic energy of the spring get transformed into potential energy. Hence there is a continuous exchange of energy from one form to another.

Slide 8: Let us now try to obtain the equation for Energy of the oscillator.

Energy of a S.H.O.

- For a simple harmonic oscillator, the displacement is given by x is equal to a cos open bracket omega not t minus phi close bracket.
- From this expression we can determine the velocity, as it is the time derivative of the displacement, small v is equal to x dot is equal to dx by dt is equal to minus omega not a sin open bracket omega not t minus phi.
- Now as we know the kinetic energy is given by half mv square.
- Hence, the kinetic energy is given by half m omega not square a square sin square open bracker omega not t minus phi.
- Hence, we have now obtained the expression for kinetic energy.

Slide 9:

Let's obtain the expression for Potential energy:

- As we know from the previous lectures, the expression for potential is given by V is equal to half k x square
- Substituting the value for x we get V is equal to half k a square cos square open bracket omega not t minus phi.
- Upon substituting the value of k we get half m omega not square a square cos square open bracket omega not t minus phi.
- Hence, we get potential energy is equal to half m omega not square a square cos square open bracket omega not t minus phi.
- This is the expression for Potential Energy.

Slide 10:

There we may now obtain the total energy:

- The total energy E is the sum of Potential Energy and Kinetic energy
- Adding Kinetic Energy and Potential Energy terms and taking common terms out we get: E is equal to half m omega not square a square open bracket sine square open bracket omega not t minus phi close bracket plus cos square open bracket omega not t minus phi close bracket.
- Hence, we have E is equal to half m omega not square a square , here using the trigonometric identity, the term in bracket becomes 1.

- Hence the expression for Total Energy E is equal to m omega not square a sqaure.
- The kinetic energy of the oscillator is maximum as the mean position.
- Hence, we get maximum kinetic energy at x is equal to 0.
- Here at mean position that is at x equal to zero potential energy is minimum or zero while the kinetic energy is maximum and is given by half m omega not square a square.
- So at mean position,since the total energy is equal to the sum of potential and kinetic energy hence ,here the total energy is equal to the kinetic energy itself since potential energy is zero.
- Similarly, PE becomes maximum at extreme position.
- Here at extreme ends that is when displacement is maximum the kinetic energy is minimum or zero while the potential energy is maximum and is given by half m omega not square a square.
- So at extreme ends ,since the total energy is equal to the sum of potential and kinetic energy hence
- Here the value of potential energy becomes equal to the total energy E, while the kinetic energy takes its minimum value of 0.

Slide 11: Diagram

Here the blue colour line represents how the potential varies with displacement ‘x’ from mean position where as the orange colour curve represents how the kinetic energy varies with displacement ‘x’.

The dotted line on top is the value of the total energy of the oscillator and at all times the total energy is the sum of the kinetic and potential energy. So if you add at any position the value of kinetic and potential energy of the oscillator it will give you the total energy.

But there are special points, where, one of the energies vanishes so we start from the left and right extreme positions. At the extreme points, the kinetic energy of the oscillator becomes zero, this can be seen from the fact that at the extreme points the orange curve becomes zero.

Where as the blue line touches the peak value hence we can say that at this points the potential energy maximizes and takes the value of the total energy whereas the kinetic energy minimizes and takes the value zero.

Now the other point is at mean position, At mean position the displacement is zero and at this point potential energy becomes zero and this is seen from the fact that the potential energy curve touches zero and at this very point the kinetic energy maximises and becomes equal to the peak value which is the total value of energy.

Slide 12:

Here are some of the references that were used in preparation of this module.

THANKYOU!

Notes: