

Question:

Sound can break glass. Which breaks most easily:

1. A glass pane exposed to a loud, short sound
2. A glass pane exposed to a certain loud tone
3. A crystal glass exposed to a loud, short sound
4. A crystal glass exposed to a certain loud tone

Strings as Harmonic Oscillators

- A string is a harmonic oscillator
 - Its mass gives it inertia
 - Its tension gives it a restoring force
 - Stable equilibrium
 - Restoring force proportional to displacement
- Restoring force determined by
 - Curvature
 - Tension

Fundamental Vibration

- String vibrates as a single arc, up and down
- Pitch (Frequency of vibration) is
 - Proportional to tension
 - Inversely proportional to string length
 - Inversely proportional to mass/length

Overtone Vibrations

- String can vibrate as two half-strings, three third-strings, etc.
- Pitches are twice, three times, etc. the fundamental pitch and are called harmonics
- Bowing or plucking a string tends to excite a mixture of fundamental and harmonic vibrations

Producing Sound

- Thin objects don't project sound well
 - Air flows around objects
 - Compression and rarefaction is minimal
- Surfaces project sound much better
 - Air can't flow around surfaces easily
 - Compression and rarefaction is substantial
- Many instruments use surfaces for sound

Vibration and Energy

- Vibration always involves two energy forms
- Energy goes back and forth between forms

Plucking and Bowing

- Plucking a string transfers energy instantly
- Bowing a string transfers energy gradually
 - Rhythmic excitation at the right frequency causes sympathetic vibration
 - Bowing always excites string at the right frequency
 - The longer the string's resonance lasts, the more effective gradual energy transfer will be

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Air as a Harmonic Oscillator

- A column of air is a harmonic oscillator
 - Its mass gives it inertia
 - Pressure gives it a restoring force
 - Stable equilibrium
 - Restoring force proportional to displacement
- Restoring force determined by
 - pressure gradient

Fundamental Vibration

- Air column vibrates as a single object
- Pitch (Frequency of vibration) is
 - Inversely proportional to column length
 - Inversely proportional to air density
- A closed pipe vibrates at half the frequency of an open pipe

Overtone Vibrations

- Open column can vibrate in thirds, fifths, sevenths, etc. (odd harmonics)
- Closed column can vibrate in three-halves, five-halves, seven-halves, etc. (odd harmonics)
- Blowing across column tends to excite a mixture of fundamental and harmonic vibrations