



PROPERTIES OF SOUND WAVES

CATEGORIES OF SOUND WAVES

- Audible sound wave
 - sound wave in the range of human hearing
 - frequency of 20 Hz to 20 kHz
- Infrasonic wave
 - sound wave with a frequency below 20 Hz
 - earthquake waves
- Ultrasonic wave
 - sound wave with a frequency above 20 kHz
 - ultrasound machines



THE SPEED OF SOUND

- Speed of sound through air depends on the temperature and density of the air
- Value increases by 0.606 m/s for every increase of 1° C

$$v = 331.4m / s + (0.606 / m / s / ^\circ C)T$$

- where T is the temperature in degrees Celsius



PG. 393 PRACTICE #1

1. If the temperature of the air in your region is $32\text{ }^{\circ}\text{C}$, what is the speed of sound in air at that temperature? **T/I** [ans: 351 m/s]

Given: $T = 32\text{ }^{\circ}\text{C}$

Req'd: v_{sound}

Analysis:

$$v = 331.4\text{ m/s} + (0.606\text{ m/s/}^{\circ}\text{C})T$$
$$v = 331.4\text{ m/s} + \left(\frac{0.606\text{ m}}{\text{s}^{\circ}\text{C}}\right) 32\text{ }^{\circ}\text{C}$$
$$v = 331.4\text{ m/s} + 19.392\text{ m/s}$$
$$v = 350.792\text{ m/s}$$

$v = 350\text{ m/s} \rightarrow 2\text{ sig digs}$



PG. 393 PRACTICE #2

2. If the speed of sound near you is 333 m/s, what is the ambient temperature? T/1

[ans: 2.64 °C]

Given: $v = 333 \text{ m/s}$

Required: $T = \text{temperature}$

Analysis: $v = 331.4 \text{ m/s} + \left(0.606 \frac{\text{m}}{\text{s}^\circ\text{C}}\right) T$

Steps: $333 \frac{\text{m}}{\text{s}} = 331.4 \frac{\text{m}}{\text{s}} + 0.606 \frac{\text{m}}{\text{s}^\circ\text{C}} T$

$$333 \frac{\text{m}}{\text{s}} - 331.4 \frac{\text{m}}{\text{s}} = 0.606 \frac{\text{m}}{\text{s}^\circ\text{C}} T$$

$$1.6 \frac{\text{m}}{\text{s}} = 0.606 \frac{\text{m}}{\text{s}^\circ\text{C}} T$$

$$\rightarrow \frac{1.6 \text{ m/s}}{0.606 \frac{\text{m}}{\text{s}^\circ\text{C}}} = T$$

$$\frac{2.64}{\frac{1}{^\circ\text{C}}} = T$$

$$2.64^\circ\text{C} = T$$

$$2.64^\circ\text{C} = T$$

MACH NUMBER

- Mach number (M)
 - the ratio of the airspeed of an object to the local speed of sound

$$M = \frac{\textit{airspeed}}{\textit{speedofsound}}$$

- Remember ratios have no units !!!!
- Sonic booms



PG. 394 PRACTICE #1

1. If the local speed of sound is 344 m/s and an aircraft is flying at 910 km/h, what is the Mach number? T/I [ans: 0.73]

Given: $v_s = 344 \text{ m/s}$

$v = 910 \text{ km/h}$

Required: $M = \text{mach number}$

Analysis: $M = \frac{v}{v_s}$

$M = \frac{253 \text{ m/s}}{344 \text{ m/s}}$

$M = 0.74$

Steps: $910 \frac{\cancel{\text{km}}}{\cancel{\text{h}}} \times \frac{1000 \cancel{\text{m}}}{1 \cancel{\text{km}}} \times \frac{1 \cancel{\text{h}}}{60 \cancel{\text{min}}} \times \frac{1 \cancel{\text{min}}}{60 \text{ s}}$

$v = 253 \text{ m/s}$



PG. 394 PRACTICE #3

3. If the Mach number is 0.81 and the speed of an airplane measured by radar is 850 km/h, what is the local speed of sound in kilometres per hour? T/1

[ans: 290 m/s = 1.0×10^3 km/h]

Given: $M = 0.81$
 $V = 850 \text{ km/h}$

Required: $V_s = \text{speed of sound}$

Analysis: $M = \frac{V}{V_s}$

Steps:

$$V_s = \frac{V}{M}$$

$$V_s = \frac{850 \text{ km/h}}{0.81}$$

$$V_s = 1.0 \times 10^3 \text{ km/h}$$



SPEED OF SOUND IN VARIOUS MEDIA

- Speed of sound depends not only on the temperature of the medium but also on the medium's properties

Table 1 Speed of Sound in Various Media

Medium	Speed of sound (m/s)
air (20 °C)	344
air (0 °C)	331
air (−20 °C)	319
glass (Pyrex)	5170
steel	5000
water	1496
wood (maple)	4110

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SOUND INTENSITY

- Loudness depends on sound intensity
- Sound intensity
 - the amount of sound energy being transferred per unit area
 - units are watts per square metre (W / m^2)
- Decibel (dB)
 - unit of sound level
 - used to describe sound intensity



SOUND SAFETY

- Exposure to high sound levels can cause hearing damage
- Damage is not reversible
- Ministry of Labour
- Musicians
- Personal listening devices



WORK

- Pg. 397 #2,3,9,10

$$f = \frac{1}{T} \quad T = \frac{1}{f}$$

Quiz tomorrow

- Universal Wave Eqn $v = f\lambda$

$$\mu = \frac{m}{L}$$

$$v = \sqrt{F_T / \mu}$$

- Monday

Take up Electricity Test.

