THE WORLD OF SOUND - IN RELATION TO NOISE MEASUREMENTS

AUDIO-VISUAL

REG. NO.M9402

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ALL INDIA INSTITUTE OF SPEECH AND HEARING: MYSORE 570 006

MAY 1995

DEDICATED TO

ALL THE HANDICAPPED CHILDREN IN THE WORLD

CERTIFICATE

This is to certify that this Indenpendent Project entitled: **THE WORLD OF SOUND - IN RELATION TO NOISE MEASUREMENTS : A AUDIO-VISUAL** is the bonafide work in part fulfilment for the First year MSc., (Speech and Hearing) of the student with Reg.No.M9402.

Mysore
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C E R T I F I C A T E

This is to certify that this Independent Project entitled : **THE WORLD OF SOUND - IN RELATION TO NOISE MEASUREMENTS : A AUDIO-VISUAL** has been prepared under my supervision and guidance.

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DECLARATION

I hereby declare that this Independent Project entitled: THE WORLD OF SOUND - IN RELATION TO NOISE MEASUREMENTS : A AUDIO-VISUAL is the result of my own study under the guidance of **Dr.(Miss) S.Nikam,** Prof, and Head of the Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other Diploma or Degree.

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INTRODUCTION

An Old Riddle asked, "What comes with a carriage and goes with a carriage and yet the carriage cannot move without it?"

The answer: "A Noise".

Many events of nature, whether the meeting of two objects or the turbulent flow of air, radiate a tiny part of their energy as pressure waves in the air. A small fraction of the energy that is scattered, thus we know of the event. Man's links to the outside world through hearing seems to be the essential "sense, the one that makes man peculiarly human.

The first step of intellectual development are beyond the deaf child"s reach. The sounds of life remain unknown. He cannot learn to imitate meaningful sounds because he cannot hear them, unless heroic efforts rescue him, he will never truly master his own language; with its offspring, speech, that gives man his superlative capacity to communicate.

The virtuosity of human hearing is as remarkable as its importance. A man can hear a mosquito buzzing outside his window, even though the power of the sound reaching him, may be no more than one quadrillianth of a watt. The ear receives an uninterrupted stream of messages from the outside world.

Thus, its important for us to know about the transmission and propogation of sound, and also have a general understanding of the fundamentals of noise and its measurements.

Along with this, we should also keep in mind that noise is different from other environmental pollutants and the marginal cost of noise measurements and control can be quite expensive, and the judgemental processes to balance cost and social benefit are difficult because of the wide range of exposures, which can produce varying degrees of effects.

In order to give meaning to the testing procedures and to provide a proper prognosis and referral action, it is vital that the audiologist have a firm grasp of the auditory process.

"HOW MUCH NOISE IS TOO MUCH NOISE?"

- To answer this we should have a knowledge of noise measurements and its propogation and transmission.

The knowledge about noise measurements, its propogation and transmission are necessary to professionals like acousticians, environmentalists, audiologists, legislators, urban transportation planners, equipment manufacturers and operators, physicians, psychologists, sociologists, civil and criminal lawyers, architects as well as teachers, students and researchers in this fields.

Being audiologists we are more concerned with the response of the human ear to a auditory stimuli.

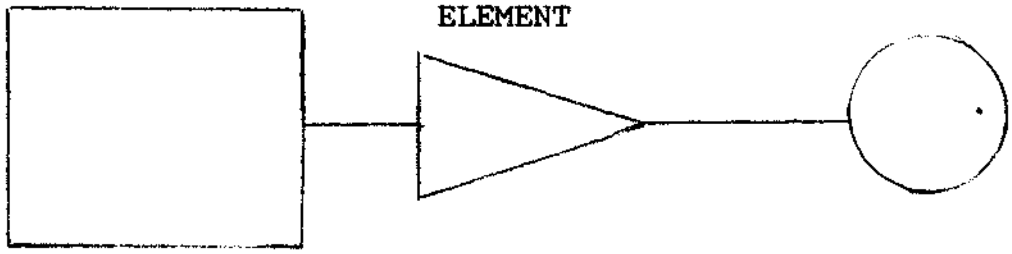
A detailed appraisal of the consequences of exposure to excessive noise and the implementation of effective noise mitigating techniques is highly dependent upon our abilities to acoustically measure and describe sources of noise in the environment before applying the relevant social indicators. The most obvious and straight forward way to quantitatively characterize the sound environment is through the utilization of noise measurement instrumentation and techniques.

It is important that the measurement of noise in an environment should be a demonstrate and reliable indicator of the sound radiating properties of sources present in the environment.

Selection of specific measurment techniques and appropriate instrumentation depends upon the characteristics of the noise source or sources to be measured, the environment in which the measurement is to take place, and the purpose or objective of the measurements.

There is a wide variety of instrumentation available for the measurement and analysis of sound. New technology developments in electronics have promoted sound measuring equipment that is stable in operation, light weight, portable and battery operated ones.

Sound measuring equipment is electroacoustic sound pressure fluctuations are transformed into corresponding electrical signals and then analysed. To accomplish this analysis, all sound measuring and analysis systems consists of 3 fundamental components.



[BROCH, 1971; EPA, 1971a; WYLE LABORATORIES, 1976]

Capabilities of noise measuring instruments are generally provided in instrument performance specifications which describe the electrical and physical characteristics of the device in terms of accuracy and tolerance, frequency response, dynamic range of operating conditions (Broch, 1971, Peterson and Gross, 1972; Wyle Laboratories, 1976).

WHY IS IT NECESSARY TO KNOW ABOUT NOISE MEASUREMENTS?

The levels and spectrum of noise is required:

* To determine the relationship between noise exposure and hearing loss.
* To obtain quantitative inforamtion.
* To specify the limits for safety or hazardous noise conditions.
* To compare the measured levels with the acceptable levels.

* To monitor the exposures for compliance with safety limits.
* To find how the reduction can be achieved most satisfactorily.

THE PURPOSE OF THIS PROJECT IS TO:

* To have knowledge of the nature of sound, its propogation and transmission.
* To know about the various instrumentation in the measurement of noise.
* To know about the need of measurements.

THE NATURE OF SOUND

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The propagation of sound:		
SLIDE 2	:	Sound needs a medium to propogate. It propogates through air for hearing. As we all know air whether at rest or in motion, is an elastic, springy stuff which transmits sound. Sound sources can be of various kinds like reeds, strings, membranes and columns of air.
SLIDE 3	:	Sounds created when some force sets an objects into vibration to the extent molecular movement of the medium in which the object is situated occurs, and a "sound wave" is propagated.
SLIDE 4	:	A sound wave has 2 parts; "compression" and "Rarefaction".

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		When a sound wave is compressed, pressure is built up which forces them to "rebound". When the pressure is removed, the particles "overshoot" their formen positions when compression ceases.
SLIDE 5	:	In the compression cycle of the particles force against each other. In the rarefaction phase they separate from each other. After they separate, another phase of compression action of the sound source. Thus alternate compressions and rarefactions, characterize the sound wave and each compression and rarefaction proceeds outward from the sound source at a steady velocity.

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SLIDE 6	:	The transmission of sound from a vibrating soruce to a receptor requires some kind of medium. The medium may be air, fluid such as water or a solid such as steel.
SLIDE 7	:	Speed of sound is affected by the temperature of the medium that transmits it. In a cold medium, molecules move slowly and reduce the speed at which sound is transmitted. When the same medium is heated, its molecules jostle one another more rapidly and speedly for the transmission of sound.
SLIDE 8	:	There are several measurable attributes of a sound wave. The ones which we shall be concerned with are frequency, intensity and phase.

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		Now, lets know about each of the following:
	»	
SLIDE 9	:	a) Frequency : We know that successive compression and rarefaction constitute one cycle of a sound wave. The frequency of a sound wave is the number of cycles that occur in a second's time. The unit for expressing frequency in cycles per sec (cps) or Hertz (Hz). The time taken for one complete cycle is known as the time period (T). The relationship of the period with frequency is f = 1/T where; f = frequency; T = period.
SLIDE 10	:	The human ear can hear frequencies from 20 Hz to 20,000 Hz. This is the audio frequency range. The ear is more sensitive

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	to the frequencies from 1000-4000 Hz. Sounds greater than 20,000 Hz or upper limit of audio frequency range are referred to as "ultrasonic". If the sound is below the lower limit of audio frequency range are referred to as "infrasonic" sounds.
SLIDE 11 :	b) Intensity: The intensity of sound refers to the "strength" of the particle vibrating. A given sound may vibrate with little or great intensity, depending on the amount of force that sets it into vibration. It is usually measured in terms of pressure expressed in "microbars" or "dynes per square centimeter". The most common reference point from which sound intensities are computed is a power of 10^{-16} watt/cm^2 or a pressure of; 0.0002 dynes/Cm^2

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	The ratio between this reference point and any given intensity is expressed in terms of a logarithmic unit called the decibel (dB).
	The most common method of measuring the intensity of sound is by determining pressure. Thus, the sound pressure level of any sound is the ratio between its measured pressure to standard reference pressure which is 0.0002 dyne/Cm^2. Similarly the intensity level of any sound is the ratio between its measured power to its standard reference point, 10^{-16} w/Cm^2
SLIDE 12 :	c) Phase: It refers to the time relationship between or more pure tones occurring simultaneously. Here you can see pairs of sinusoidal waves of

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		identical frequency, differing in phase.
SLIDE 13	:	Waves can either be of puretones or complex sounds. When 2 or more pure tones are combined then the resultant is called a complex wave. Picture "a" is an example of a complex wave. When two waves are of equal frequency and intensity then they are said to be in phase and the combination of these waves is twice as big at each point along the line as in picture "b". When the tones are separated by half-a-cycle, the tone will cancel each other and the amplitude will be zero.

OTHER ASPECTS OF SOUND

SLIDE 14	:	Sound Field: Any area in which sound waves are present can be called a sound field.

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SLIDE 15	:	There are different types of sound field. They are, a) Free field b) Reverberant field c) Near field and far field.
SLIDE 16	:	a) Free field: Here the sound waves are allowed to travel without obstruction, thus has no reflections or diffraction or absorption. b) Reverberant field: Its a sound field in which multiple reflected waves are present. A highly reverberant room is referred to as a true room. Whereas a room which has very little reverberation is called a dead room. Like radio studios.
SLIDE 17	:	c) Far field and near field: As shown in the figure, the immediate vicinity of the source

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		is known as the near field. Here the particle velocity is not in the direction of propagation of the sound wave. The extent of near field depends on many factors such as, the frequency, dimensions of the source and phase of the radiating surface. In the far field you can see that the SPL reduces by 6 dB each time the distance between the measuring microphone and the source is doubled. The particle velocity is in the direction of propagation and the intensity is proportional to the root mean square pressure.
SLIDE 18	:	Spectrum : For any sound, graphical representation in terms of frequency components and their relative amplitude is obtained by means of "FOURIER SPECTRA". The

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		graph of this function is called spectrum. It's possible to have spectrum of puretones and also for complex tones. The spectra of the sound signal can be varied by the use of filters.
SLIDE 19	:	Noise: Noise is defined as any signal which is complex and there is periodicity in pressure changes over time and they are considered as random oscillations.
SLIDE 20	:	There are different types of noise: They are; a) Complex noise b) White noise and Broad band noise c) Pink noise d) Saw tooth noise e) Narrow band noise f) Speech noise and g) Impulsive noise.

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SLIDE 21	:	Now, let us know about each of them. The complex noise contains low frequency puretone with harmonics and intensity becomes less at higher harmonics. It is useful to mask low frequencies. The white noise or the broad band noise has equal energy/cycle and covers a relatively broad range of frequencies. It contains equal intensity at its components of frequencies upto 6 KHz. It can be used for masking speech.
SLIDE 22	:	Pink noise has a broad spectrum of noise with approximately equal energy per octave below 2 KHz. The spectrum level decreases at the rate of 3 dB per octave above 2 KHz. Saw tooth noise is produced by driving an earphone with a saw

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		tooth wave. It has fundamental frequency of 120 Hz. It has equal intensities at its harmonics.
		Narrow band noise is obtained by filtering white noise through band pass filters. The redundant broad band components are removed to make masking more effective.
SLIDE 23	:	Speech noise is obtained by filtering white noise above 1 KHz at a rate of 12 dB per octave roll off. It is mainly a low frequency spectrum composed of white noise and resembles the speech spectrum. It is useful for masking speech.
		Impulse noise is a sound with a rise time of not more then 35 sec. to peak intensity and duration of not more than 500 msec.

THE NEED AND USE OF NOISE MESUREMENTS

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SLIDE 24	:	Noise measurement is done whenever you choose a site, especially for: construction of audiometric rooms, or to check up the noise levels in an audiometric room periodically. To study the adverse effect of noise one must be use as how much noise (intensity) is acting upon to produce such an effect. From industrial point of view, the noise measurement is a must economically, for eg. loss in industry or compensation to be paid for the work for hearing loss consequent to noise exposure from the particular industry. For noise control.

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	To study the ambient noise in a community because a industry or a theatre in a residential area may create disturbances. Thus the need and use of such measurements can be justified.

FACTORS CONSIDERED IN CHOOSING INSTRUMENTS FOR NOISE MEASUREMENTS

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SLIDE 25	:	It is important for experimenter to select a particular instrument or combination of instruments which best fits its requirements for noise measurments.
SLIDE 26	:	The first concern in the field of noise measurments is the choice of microphone. When choosing the microphone one should consider the following factors: A) The properties of sound field: Whether free field or closed chamber; density and wave velocity in the medium; the important range of sound pressure level and important frequency range to be measured.

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B) The desired precision of measurement:

- Sensitivity tolerance
- Frequency distortion tolerance
- Phase distortion tolerance
- Non linear distortion tolerance.
- Self noise tolerance.

C) The environmental conditions of measurement: Should be measured as they play a very important role in measurement of noise. It is important to consider the back ground noise level, temperature, humidity, atmospheric pressures, wind, electromagnetic fields, mechanical shock and weight and space 1imitations.

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D) Various other factors should also be considered while selecting a microphone. The sound levels whether low or high; the frequency of the noise low or high; the direction of arrival of sound at the microphone, the position of the microphone.

SLIDE 27 : When noise measurements are made it is important to choose the correct weighting networks. It is been found that the observer can affect the measured data if close to the microphone. When the measurements are made in a live room and not close to the surface, the affect is usually not important. But, affects the measurements if the measurments are made close to the source, the observer should stand on side of the direct path between the source and the microphone.

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SLIDE 28	:	When the measurement is made in an anechoic room the instrument and the observer should be in the other room, with only the source, the microphone the extension cable and a minimum of supporting structure in the room.
SLIDE 29	:	All necessary objects should be removed from the measurement room. This is a must because objects in the room reflect the sound waves just as do the walls of the room. When it is imperical to follow this principle, it is essential to treat the objects with the obsorbing material.
SLIDE 30	:	One of the major important consideration is the influence of external factors upon the measurements ie. how the

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	environment affects the readings. It has been found that barometric pressure can affect the calibration of the instrument. The two elements that are sensitive to temperature changes are the batteries and the microphone. As the temperature decreases, the life of the batteries decreases. Thus, when dealing with noise measurments, one should know the extent of reliable measurements that can be made with the same batteries. This is more true with sub-zero temperatures. Some microphones are sensitive to temperature, like the condensor microphones are less sensitive to temperature and the Rochelles salt microphones are very sensitive to temperature. The microphones are found to be sensitive to humid temperatures especially the

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		condensor microphones. The modern ceramic microphones may be used in relative humidities of 0-100%.
SLIDE 31	:	Whenever the outdoor measurements are made, the frequency response characteristics of microphone is affected mainly by flow of wind. The magnitude of the noise increases with the increase in the wind speed. For a given microphone with a wind screen, one may determine whether or not the measured noise level is caused by the wind or comes from the noise source.

NOISE MEASUREMENT PROCEDURES

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SLIDE 32	:	Before the measurement procedures are taken up they must be defined to take into account the place or places that microphone should be sited in relation to the noise source and the manner in which the source must be operated to display a representative noise output.

Depending upon the purpose of the measurements and the desired accuracy of the result a wide range of measurements techniques and source level descriptions should be understood.

Noise measurment procedures varies from country to country. The goal of noise mesurement is to make valid, accurate and through measurments of noise situation under study.

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	The purpose for which measurements are made and what information is required should be specified.
	The type of noise source under consideration whether ambient noise, traffic noise, aircraft noise etc.
	The type of noise that is to be measured whether impulse, continuous, interrupted etc.
	The place where the measurement is to be made whether indoor or outdoor and the position of the source in the environment.
	The placement of the microphone with respect to the source.
	Selection of the appropriate instruments so as to get the necessary information.

METHODS OF NOISE MEASUREMENT

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SLIDE 33	:	The absolute methods are divided into: - survey method - Precision method and - Engineering method.

INSTRUMENTS FOR NOISE MEASUREMENTS

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SLIDE 34	: Microphones : A microphone is a transducing device which converts acoustical energy into electrical energy. The three basic types of microphone commonly used for noise measurments are: a) Piezoelectric microphone b) Dynamic microphone and c) Condensor microphone
SLIDE 35	: The microphone used for the measurment purpose should have the following characteristics: - Sensitivity - Variation of response with frequency and the ambient conditions - Directional properties - Non linear distortion - Impedance

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SLIDE 36	:	Now, lets know about the condensor microphone: In the condensor microphone the incident pressure wave causes the microphone to deflect slightly and consequently the diaphram moves along the back plate thus causing a change in capacitance between the diaphragm and a flat electrode positioned parallel to and behind the diaphram. Thus, the acoustic energy is converted into electrical energy.
SLIDE 37	:	The widest frequency range of a condensor microphone is obtained when the diaphragm is critically damped and the high frequency range can be got by decreasing the size of the diaphragm viz. the smaller diameters provide higher limits for the frequency and the dynamic ranges at a lower sensitivity.

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SLIDE 38	:	Based on this concept, the condensor microphone has different sizes with respect to the diameter, for example, 1 inch, 1/2 inch, 1/4 inch and 1/8 inch. Thus, the microphone size may be used with sound measuring instruments to cover a wide range of frequencies from a few hertz to over 100,000 Hz. The 1/2 inch, 1/4 inch and 1/8 inch condensor microphones have a dynamic ranges of about 30-160 dB, 50-175 dB and 60-185 dB respectively.
SLIDE 39	:	Advantages of the condensor microphone: - As they are small in size they create minimum disturbance in the sound field. - They give a wide frequency range depending upon the size of diaphragm.

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		- They have good long term stability. - It is not permanently damaged by exposure to humidity extremes. - The change with respect to the effect of ambient pressure change 0.0003 dB/mm Hz is indicative of its suitability for extended long term monitoring situations. - They have low sensitivity to the mechanical vibrations of the unit as a whole. - It can be easily calibrated.
SLIDE 40	:	Disadvantages of the condensor microphone: - It has low capacitance which results in high impedance at low frequencies. - High impedance of the condensor microphone makes it susceptible

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	to troubles from electrical leakage caused by high humidity.
	- The condensor microphone has a thin diaphragm which when exhibited to very high intensity may damage it.
	- The air leak from leakage path of the condensor microphone reduces the low frequency response of the microphone. In order to prevent this the hole is vented to the atmospheric pressure at the point of measurement.
	- The condensor microphone is sensitive to the moisture.
SLIDE 41	: Uses
	- It is used in precision acoustic measurements.
	- It is used in pressure variation measurements.

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SLIDE 42	:	PIEZO ELECTRIC MICROPHONE: The piezo electric microphone consists of a diaphragm which is used as a force collector. The piezo electric material is placed behind the diaphragm so that force exerted on the diaphragm strains the crystal and results in the production of voltage which is proportional to the sound pressure level by the piezo electric action.
SLIDE 43	:	ADVANTAGES: The type of construction is more rugged than either the electret or condensor microphone because the piezo electric material behind the piezo electric material behind the diaphram and gives support to it.

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	- It has capacitance and hence no need for the preamplification of the output signal. - The performance of the microphone is unaffected by the change in the temperature and the effect of the atmospheric pressure. - It has a wide dynamic range. - These microphones are cheaper comparitively.
SLIDE 44	: DISADVANTAGES: - They have a very low acoustic output. - These microphones are highly subjected to vibration changes. - When Rochelle salt is used, there is irreversible change at tempeature above 55.6c - Exposure to unprotected Rochelle salt results in the destruction of the crystal due to the humidity changes.

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SLIDE 45	:	SOUND LEVEL METER: A sound level meter is an instrument designed for the measurement of sound pressure level (SPL).
SLIDE 46	:	The SLM consists of a transducer (microphone) to sense the sound wave pressure and convert pressure fluctuations into an electrical voltage, an input amplifier to raise the electrical signal to an usable level a calibrated attenuator to adjust the amplification to a value appropriate to the sound level being measured. An indicating meter (instrument) to display the measured level. The weighing networks to modify the frequency characteristics of the instruments response. An output amplifier and calibrated output attenuator. An output jack to

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		carry the signal to additional instrumentation for further analysis.
SLIDE 47	:	The SLMs are of different types: - Precision sound level meters with microphone and weighting networks. - Sound level meters with octave filter set type. - Sound level meter with its output terminals allowing the noise signal to be recorded or monitored on an external recording device if required like a level recorder. - Impulse precision sound level meter.
SLIDE 48	:	As the human ear responds differently to different frequencies, many sound level meters contain systems called

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		weighting networks; which are filters to alter the responses of the instruments much as the ear does at different levels. The SLMs are normally equipped with foure frequency weighting networks, A, B, C and D, that can be used to approximate the frequency distributions of noise over the audible spectrum.
		The A - frequency weighting is used for levels below 55 dB.
		The B - frequency weighting is used for levels of 55 to 85 dB.
		The C - frequency weighting is used for levels above 85 dB.
SLIDE 49	:	USES OF SLM:
		- It is used in community and industrial noise measurements.

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		- Checking compliance with noise rating recommendations. - Traffic noise measurements.
SLIDE 50	:	FREQUENCY ANALYZERS: When the sound to be measured is complex consisting of a number of tones or having continuous spectrum the rough estimate of frequency response characteristics provided by the sound level meter weighting networks does not give enough information. In such cases the output of the SLM can be fed into a suitable analyzer which will provide more specific frequency distribution characteristics of the sound pressure.
SLIDE 51	:	There are 3 types of frequency analyzers. They are: 1) Octave, half octave analyzer

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		2) Narrow band analyzer 3) Band width analyzer Of all the 3 analyzers the octave analyzers are the most common type of analyzers used for noise measurements. They provide information of spectral distribution with a minimising number of measurements.
SLIDE 52	:	The octave filter set has different controls, the input and output filter switch, weighting potentiometers and a weighting switch.
SLIDE 52	:	USES - It is used in combination with the sound level meter. - It is used in noise and vibration analysis.

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		- It is used in distortion measurements. - It is used in calibration of audiometers. - It is used in building acoustic measurements.
SLIDE 53	:	NOISE DOSEMENTERS : Noise dosemeters are portable, pocket size instruments, having facility for noise measurement and computing normally found in instruments of much greater size. There are also different controls; they are the microphone input; external preamplifier input, charge input, percentage display, on-off (Reset).
SLIDE 54	:	It is designs to be easily worn by individuals without interfering with their work activities and measures their true accumulated noise exposure.

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SLIDE 55	:	The full amount of noise exposure of the employee and at the end of the work shift gives the percentage of allowable noise exposure received by him. The readout is presented on a clear, easy to read liquid crystal display which can be concealed by the front panel of the meter.
SLIDE 56	:	The dosemeter computes the dosage or time equation for the entire working day. Where "C_n" is the total time exposure to noise level "n". "Tn" is the total time permitted to that particular noise level and "D" is the dose computation. $D = \frac{Cl}{Tl} + \frac{C2}{T2} + \frac{C3}{T3} + \_\_\_\_ + \frac{Cn}{Tn}$
SLIDE 57	:	The dose consists of a microphone for sound pick up and some models

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		used in a built in microphone, some models have a microphone attached to the dosemeter through a lead in wire. Further the microphone is attached to an amplifier, a weighting circuit, root mean square detector, microcomputer chip and a storage chip.
SLIDE 58	:	Advantage of Dosemeters: - The procedure is simple and produces a single unit of exposure which is either less than, equal to or greater than permissible exposure levels. - The device works well in varying noise levels. - The person making the determination of noise elvel needs to be presented during the entire measurement period.

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- The unit handles multiple determination concurrently.
- Dosemeters are cost effective relative to more expensive analytical equipment needed to provide comparable measure.
- They can be worn under ear muffs.
- It does not weigh more than an ear borne hearing aid.
- It does not disturb the wearer.
- The device facilitates the new possibilities of prospective studies of individual total daily exposure to all kinds of noise including impulsive noise.
- The position of the microphone at the entrance of the ear canal makes the measurement of the actual SPL entering the ear canal possible and thus eliminates the disadvantages of

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other measuring methods, concerning the evaluation of the baffling effect and the distance effects.

SLIDE 59 : Disadvantges of Dosemeters:

- Accuracy is limited.
- Dosemeters are susceptible to nonintentional or intentional errors which may influence readings (such as employees tapping on or singing into dosemeter microphones).
- Measurments may be affected by body shielding.
- Calibration may drift out of adjustment over long measurement period.
- With the exception of certain more expensive pieces of equipment, no information is provides on noise level history.

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	- Dosemeters are inaccurate if impulse or impact noise is present.
	- Dosemeter may be inherently-inaccurate owing the 35 dB doubling rate employed in the electronic circuits.
SLIDE 60	: USES
	- Short and long duration measurement of accumulated noise dose as percentage of maximum, permitted dose.
	- Short and long duration measurement of L_{eq} with aid of readout conversion tables.
	- Assessment of hearing loss risk.
	- Indication that allowable noise dose is expanded.
	- Indication that allowable exposure time has expired.
	- Noise excess indication warning of continuous and impact noise hazard.

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SLIDE 61	:	GRAPHIC LEVEL RECORDER : It provides a continuous written record of the output level. It provides records in the conventional rms logarithmic form used by sound level meters, thus the data may be read directly in dBs. The level recorder is basically a recording voltmeter designed to accurately recold the RMS, average or peak level of an AC signal in the frequency range from 2 Hz to 200 KHz as well as DC signals.
SLIDE 62	:	The different controls on the level recorder can be divided into the - - Top panel controls - The side panel controls - The rear panel controls.

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SLIDE 63	:	USES OF THE GRAPHIC LEVEL RECORDER: - It can be used for recording of AC signals from 2 Hz to 200 KHz. - Recording of DC signals - X-Y recording - Statistical level analysis - Automatic recording of: * Frequency analyses * Frequency response curves * Directional characteristics * Reverberation decay curves * Sound and vibration isolation - Measurement of sound intensity - Input/output analysis of electronic and electrical system and control system analysis.
SLIDE 64	:	TAPE RCORDER : It has become an indispensable tool in noise measurements.

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		In brief, let us know about the parts of the tape recorder. It consists of an recording system, reproducing systems, record head, playback head, magnetic tape, tape supplier and an tape take up system.
SLIDE 65	:	The recorder are of 2 types:

1) Spool type:

Spool recorder	Spool deck
It has a power amplifier	It does not have a power amplifier

2) Cassettes type

Recorder	Deck

In the last several years the popularity of th cassette tape formate has grown enormously. But the quality of recording is good in the spool type than the cassette one.

VISUAL		AUDIO
SLIDE 66	:	USES: It is used for field and laboratory recording of vibration and sound data. - Collection, storage and reproduction of data for detailed laboratory investigation and frequency analysis. - Time and frequency transformations Tape loop repetition of short duration events for frequency analysis.

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