**Definition of terms**

- The radio, microwave, radar, infrared, visible light, and ultraviolet regions of the electromagnetic spectrum…
  - Considered to be non-ionizing

- Electromagnetic radiation consists of vibrating electric & magnetic field.
There is no sharp subdividing line between the infrared, visible, and ultraviolet regions—they are all manifestations of the same kind of electromagnetic radiation, differing from each other only in frequency, wavelength, or energy level.

It is convenient, however, to separate these regions into distinct groups because of the nature of the physical and biological effects which are produced.

There are 3 basic ways in which electromagnetic (EM) waves may differ:

- In strength, the intensity of the EM forces
- In frequency
- In wavelength

Infrared (IR)

- Most infrared (IR) radiation is obtained as radiation from hot bodies and are commonly known as ‘heat’ waves.
- Infrared waves are emitted from the rotations and vibrations of the atoms making up the hot body.
- Visible light is emitted as the temperature of the hot body is raised; some visible light is also produced by electron transitions.
- Visible and ultraviolet (UV) light also results when an electric current is passed through a gas.

Electrons excitation vs overlap into the region

- The UV frequency frequencies are due to electronic excitations. As the energy of excitation increases there will be an overlap into the lower-frequency limit of the X-ray region.
- High-speed electrons impinging upon heavy-metal targets can produce X rays. As the energy of these high-speed electrons is increased, the radiated frequencies increase and overlap into the gamma ray region.

The entire electromagnetic spectrum is roughly divisible into two broad regions:

- The upper region (shorter wavelength) is of particular concern to the physicists and physical scientists, who describe radiation in terms of wavelength (angstroms, centimeters, microns, millimeters)
- The lower region (longer wavelengths) has been explored by the communications scientists and engineers, who prefer to describe electromagnetic radiation in terms of frequency (Hertz, megaHertz, cycles)
The Joule, the calorie, and the erg are physical units which measure the total quantity of energy or work. The watt, the calorie per second used to measure the time rate at which this is emitted. The intensity or energy density is expressed in terms of the energy incident upon a unit area or absorbed in a unit volume.

Radiation having a wide range of energies form the electromagnetic spectrum. The spectrum has two major divisions: non-ionizing and ionizing radiation.

Unlike ionizing radiation, non-ionizing radiation cannot ionize absorbing material. However, it has the ability to increase the temperature of a target material. Depending on exposure time and energy concentration, it can lead to burns.

Radiation that falls within the ionizing radiation range has enough energy to remove tightly bound electrons from atoms, thus creating ions. This is the type of radiation that people usually think of as ‘radiation.’ We take advantage of its properties to generate electric power, to kill cancer cells, and in many manufacturing processes.
Advantages

We take advantage of the properties of non-ionizing radiation for common tasks:

- microwave radiation -- telecommunications and heating food
- infrared radiation -- infrared lamps to keep food warm in restaurants
- radio waves -- broadcasting

Includes...

- With laser light, the radiofrequencies (including radar and microwave), along with infrared and visible light, and the ultraviolet regions of the electromagnetic spectrum are commonly considered to be non-ionizing radiation.

Range of Non-ionizing Radiation

Non-ionizing radiation ranges from extremely low frequency radiation, shown on the far left through the audible, microwave, and visible portions of the spectrum into the ultraviolet range.

Sumber EMR

- Osilasi sirkuit elektrik → gelombang radio panjang
- Infra Merah (IM) berasal dari benda panas (atom berotasi dan bervibrasi) → heat waves
- Cahaya tampak dapat terjadi bila benda panas dinakikkan suhunya, atau ada transisi elektron
- Ultra violet (UV) berasal dari ekstasi elektronik, semakin kuat ekstasi semakin mendekati gelombang pendek dan X-ray
- Aliran listrik lewat gas → cahaya dan UV
- X-ray didapatkan dari elektron berkecepatan tinggi yang ditumbukkan pada logam berat. Bila energi meningkat, maka X-ray akan mendekati sinar γ

- Intensitas radiasi dari UV dan IR penting karena efek biologinya pada kulit dan mata
- Intensitas suhu untuk diukur karena alat pengukur harus sensitif terhadap panjang gelombang yang dimaksudkan
- Batas eksposur untuk UV diyakini di USA sebesar 100 J/m² pada 200 nm, dan menurun 34 J/m² pada 280 nm, meningkat sampai 10 000 J/m² pada 315 nm → panjang gelombang 230-300 nm paling berbahaya
- Ultrasonic digunakan dalam kegiatan pencucian. Bila diemisikan pada intensitas yang cukup tinggi dapat merusak, tapi belum ada standar untuk ekspor pada mata atau telinga
- Laser menyebabkan kerusakan karena energi terkonsentrasi pada area yang kecil dan bila difokuskan dapat menyebabkan terbakarnya kulit dan retina mata
- Microwave digunakan untuk memanaskan dan memasak di tempat komersil, industri, atau domestik; juga dihasilkan dari transmitter radio dan radar. Microwave oven yang boleh berbahaya, karena absorpsi energi yang tinggi dapat menyebabkan pemanasan lokal yang cepat, terutama bila materi mengandung air → terjadi resonansi frekuensi dari molekul air
Contoh kegiatan sumber ERM

- Welding equipment
- Stroboscopes
- Carbon arcs
- Scientific equipment
- Surveying
- Mercury lamps
- Communication systems
- Lasers for entertainment
- Communication systems
- Ovens
- Sun-ray lamps
- Ovens

Bahaya

- Energi (E) gelombang EMR berbanding terbalik dengan frekuensi, semakin rendah frekuensi, semakin tidak berbahaya radiasinya.
- Bahaya utama EMR adalah ‘over heating body tissues’
- Tingkat keamanan didasarkan pada jumlah max energi/dtk yang dapat didisipasi oleh unit area dari permukaan tubuh \( \rightarrow \) power surface density, dalam satuan Joules/dtk/m² atau watts/m², atau mW/cm²

Prinsip penentuan safety standards

1. (a) tidak ada efeknya
   (b) bila efek dideteksi tapi tidak ada perubahan efisiensi fungsi
   (c) ada stress dirasakan tapi hanya dalam batas kompensasi fisik yang normal
2. Beberapa bagian tubuh seperti kornea mata memerlukan ambang batas yang lebih rendah (aliran darah sedikit, sehingga tidak mampu mendisipasi panas)
3. Beberapa sumber berupa pulsa \( \rightarrow \) ada kemungkinan nilai ‘peak’ yang merusak
4. Absorpsi energi microwave tinggi \( \rightarrow \) pemanasan lokal yang cepat (jaringan tubuh manusia banyak mengandung air)

LASER (1)

- Light Amplification by Stimulated Emission of Radiation
- Karakteristik: high intensity, single \( \lambda \) (monochromatic), koherent \( \rightarrow \) garis lurus, frekuensi beragam
- Macamnya: solid state, gaseous state, semiconductor/injection
- Mekanisme kerja: sumber sinar \( \rightarrow \) eksitasi atom \( \rightarrow \) drop off + foton \( \rightarrow \) osilassi foton antara permukaan reflector \( \rightarrow \) foton \( \rightarrow \) laser
- Kegunaan:
  - ukur jarak dalam surveying
  - welding/micro machining fine parts
  - bloodless surgery (retina, kanker, microscopic surgery)
  - communication signals
  - drilling tunnel, dll

LASER (2)

- Bahaya: dari sinar laser dan dari peralatan
  - sinar laser: kerusakan mata (0.1 Watt), kulit terbakar, terbentuk gas \( O_2 \), IM, UV, elektrik shock, luka bakar, X ray (kalau high voltage): 15000 volt
  - peralatan: ada cryogenic gases (liquid \( N_2, He \) \( \rightarrow \) luka bakar di kulit, defisiensi \( O_2 \) bila ada bocoran gas; pelarut yang mudah terbakar oleh sinar laser
- Pengendalian: minimal eksposur mata; diklat bagi operator; tidak boleh ditinggal selama operasi; tidak boleh pakai binokular, jarak dekat jangan pakai reflektor, pakai sudut, pakai diffuse reflector; awas refleksi buliran hujan

<table>
<thead>
<tr>
<th>Medium</th>
<th>( \lambda )</th>
<th>Optical</th>
<th>Type</th>
<th>Power limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruby</td>
<td>6943</td>
<td>Picosecond</td>
<td>Solid</td>
<td>100-150 Watts</td>
</tr>
<tr>
<td>Helium</td>
<td>5328</td>
<td>Nanosecond</td>
<td>gas</td>
<td>5-10 watts</td>
</tr>
<tr>
<td>CO2</td>
<td>10600</td>
<td>Nanosecond</td>
<td>gas</td>
<td>5-50-200 Watts</td>
</tr>
</tbody>
</table>
Lasers

The laser beam travels in straight lines and does not spread out as ordinary light does. The energy content of the laser is therefore confined to a small diameter.

The small He-Ne gas laser has been used for highly precise distance measuring in surveying. The US Coast and Geodetic Survey presently uses laser geodimeters.

Lasers

In another application, the laser beam is used for welding or micromachining fine parts. The laser photo-coagulator is used by some surgeons to repair torn retinas.

The laser beam can be used to transmit communication signals. This will probably be the most obvious use of the laser beam. A single laser beam, theoretically, can carry as many messages as all the radio communication channels now in existence. The main problem is that no light beam will penetrate fog, rain, or snow very well.

Laser beams will crumble rock and may be used in the future for drilling tunnels in rock.

Lasers

Hazards:

0.1 watt laser is considered a potential ocular hazard, while a 100 watt light bulb is not. The principal reason for this is that the laser can be effectively a point source of great brightness close to the source and the light is emitted in a narrow beam, whereas conventional sources of illumination are bright, and emit light in all directions.

Light from a laser entering the eye is concentrated 100,000 times at the retina. Because of this focusing effect, the eye is by far the organ of the body most subject to damage. Hence, injury to the skin is seldom of concern except in dealing with very high-powered lasers.

Lasers

Viewing the direct beam of a laser through binocular could increase the intensity level at the eye by as much as 49 times.

RADAR (1)

Radio Detection and Ranging
- Klasifikasi
  - beberapa mm – beberapa m
  - Freq: 100 – 100 000 MHz
- Penggunaan: sounding, display → informasi; mengukur kecepatan laju lintas, pemetaan iklim, menjelajah dan identifikasi bahaya → beri peringatan
- Bahaya:
  - voltase tinggi → X ray
  - termal → hazard kebakaran, awas metal, flash bulbs
  - gas toxic
  - hazard elektrik
  - api, explosive (gas, uap, fumes)
  - handling material sewaktu operasi

RADAR (2)

- Efek: tergantung intensitas, waktu exposur, frekuensi radar, orang gemuk atau kurus, orang berada dekat obyek lain apa?
  - Mata, testes, k. empedu, GI track, obyek metal di badan
  - Freq rendah: penetrasi dalam, panas difus, merata, localized dibawah kulit
  - Freq 3000 MHz → suhu tinggi → max di bawah kulit
  - Bagian badan tanpa saraf sensorik tidak punya mekanisme mengeluarkan panas
  - Pencegahan:
    - jangan dekat antenna, jangan bawa foto flash bulb, pre-med exam: sehat, mata badan, tidak ada metal di badan; periodik exam bila paparan > 0,01 W/cm²
**RADAR**

"Radio detection and ranging", is that group of radio detecting instruments that operate on the principle of microwave radiation in a wavelength range from several meters (m) to several millimeters (mm). The comparable frequencies are of the order of 100 MHz to 100,000 MHz.

A pulse of energy is emitted by the transmitter to be picked up as an echo signal by the receiver. The signal thus received is converted by a display or sounding device into usable information.

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**HAZARD:**

The health, electrical, and fire hazards involved in the handling and use of radar sets include the following:

1. X radiation from high-voltage tube.
2. Radioactivity from radioactive activators used in certain radar switching tubes.
3. Thermal effects of electromagnetic radiation
4. Toxicological hazards of gas fills as used in certain waveguides.
5. Electrical hazards connected with high-voltage equipment
6. Fire hazards of flammable gases, fumes, vapors, explosives, and other highly combustible materials.

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The amount of heating produced in the body depends primarily upon the field strength and duration of exposure, but is also affected by the frequency of the radar unit.

There is no reason to believe that any frequency is harmful when field strength is low. Frequencies in the range of 3000 MHz can produce regions of high temperature.

Parts of the body most likely to become damaged include the eyes, gastrointestinal tract.

Metal plates, pins, and other metal implants in the body tend to concentrate the heating effects of radiated energy at the points of implant, thus subjecting these areas to greater tissue damage.

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**Precautions.**

The point of exposure of a person to radar energies is usually near the front of the antenna and within its beam. Radar units such as those used to measure traffic speed or to map weather present no significant hazard unless they are viewed from directly in front of the antenna, while the unit is operating, at a distance of a few feet.

Radar workers should at no time look directly into a radar beam from a high-energy unit. They should view the interior of microwave tubes, waveguides, and similar equipment only through a remote viewing device such as a periscope or telescope.

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Personnel who work in or around high-power radar antennas or radar test equipment should be adequately supervised and instructed to minimize the exposure received.

They should work at as great a distance from the beam as practical and should expose themselves to it as infrequently and briefly as possible.

Checked medically: general physical condition and blood condition.

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**UV**

- Source
- Purpose
- Danger effect
- Control
**Effect of electromagnetic radiation on the eye**

The eye is the most visibly vulnerable part of the body to the various electromagnetic radiations, with possible exception of the obvious sunburn of the skin at times caused by overexposure to UV.

The susceptibility of the eye is partially due to its being an optical instrument, equipped to receive radiations not entirely limited to the visible portion of the electromagnetic spectrum.

**Ultra Violet (UV) radiation**

The UV spectrum has been further subdivided into 3 regions:
- The near 4000 to 3000 Å
- The far 3000 to 2000 Å
- The vacuum 2000 to 40 Å

The biological effect upon exposure to UV radiation can also be used to classify various portions of the UV spectrum.

The region between 3200 and 2800 Å is noted for its bactericidal or germicidal effect.

The region between 2200 Å and 1700 Å is the most efficient wavelength range for the production of ozone. The UV radiation in this wavelength range is strongly absorbed by air.

UV radiation has been used in killing of bacteria and molds, and for other therapeutic effects.
Ultra Violet (UV) radiation

The most important application of UV radiation is in the production of visible light from fluorescent lamps. The most common exposure to UV radiation is from direct sunshine. Men who continually work outdoors in the full light of the sun may develop tumors on exposed areas of the skin. These tumors occasionally turn malignant.

UV radiation from the sun also increases the skin effects of some industrial irritants. After exposure to compounds such as coal tar or cresols, the skin is exceptionally sensitive to the sun. Even a short exposure in the late afternoon when the sun is low is likely to produce a severe sunburn.

There are other compounds which minimize the effect of UV-rays. Some of these are used in certain protective creams.

Electric welding arcs and germicidal lamps are the most common strong producers of UV radiation in industry.

Other uses have been in advertising, entertainment (go-go dancers), crime detection, photo engraving, and air, water, and food sterilization.

The total intensity of UV radiation incident on the occupant for 7 hours or less, should not exceed 0.5 micro W/sq cm and, for continuous exposure (24 hours a day), should not exceed 0.2 micro W/sq cm of wavelength 2537 Å.

Visible Light

- Source
- Purpose
- Danger effect
- Control

CAHAYA (visible energy) (1)

- Klasifikasi: EMR 4000-7500Å, polichromatik
- Sumber:
  - benda dengan temperatur tinggi sehingga mengeluarkan gelombang yang tampak
  - aliran listrik yang melewati gas → timbul cahaya atau UV
- Efek: sensasi terang/brightness
- Pengukuran:
  - intensitas: satuan candle
  - rate of flow: satuan lumen=flux (1 lumen=flux pada 1 foot² permukaan bola, dengan radius 1 foot sumber cahaya 1 candle, dan radiasi ke segala arah)
  - iluminasi diukur dengan foot-candle
  - brightness diukur dengan foot lamberts

Contoh: cahaya dengan 100 ft candle, mengenai dinding yang 100% merefleksikan cahaya maka brightness = 100 foot lamberts

CAHAYA (visible energy) (2)

- Pekerjaan yang memerlukan ketelitian, rinci, dan lama kerja, maka kuantitas iluminasi menjadi penting
- Iluminasi dapat menyebabkan kecelakaan (silau, adaptasi kurang cepat), sakit mata, kelelahan mata

<table>
<thead>
<tr>
<th>NAB:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
</tr>
<tr>
<td>Assembly Rough easy seeing medium fine</td>
</tr>
<tr>
<td>Building General construction Excavation work</td>
</tr>
<tr>
<td>Inspection Ordinary Difficult Highly difficult Locker room</td>
</tr>
</tbody>
</table>
Visible Light

The visible energy portion of the electromagnetic spectrum occupies the region between 4000 Å and 7500 Å. Exposure of the human eye to high brightness levels evokes a number of physiological responses. The subjective feeling of visual comfort is perhaps the most important criterion to be used in setting safe exposure levels to polychromatic visible light.

Units of measurement of light

The intensity of visible radiation is measured in units of candles. The rate of flow of light, referred to as luminous flux, is measured in lumens. One lumen is the flux on one square foot of a sphere, one foot in radius with a light source of one candle at the center, and radiating uniformly in all directions. Foot candles refer to a unit of illumination, which is the direct measure of the visible radiation falling on a surface. Foot lamberts represent the unit measure of the physical brightness of any surface emitting or reflecting visible radiation. For example, if 100-foot candles are incident on a 100 per cent-reflecting white surface, the physical brightness of the surface would be 100 foot lamberts.

Industrial lighting

Adequately well-balanced levels of illumination are essential in establishing safe working conditions. Industrial lighting involves a wide variety of seeing tasks, operating conditions, and economic considerations. Some less tangible factors associated with poor illumination are important contributing causes of industrial accidents. These are: direct glare, excessive visual fatigue, accident may also be caused by delayed eye adaptation when coming from bright surroundings into dark ones. The purposes of industrial lighting are to help provide a safe working environment, to provide efficient and comfortable seeing, and to reduce losses in visual performance.

Industrial lighting

The highest illumination levels are listed for tasks requiring fine detail, low contrast, and prolonged work periods, such as detailed assembly and fine layout and bench work. Therefore, in general, brightness is important as the one controllable factor. Brightness resulting from the light on the task and its surroundings in the visual field may be controlled within wide limits by varying the amount and distribution of light. The degree of accuracy required, the fineness of detail to be observed, the color and the reflectance of the work, as well as the immediate surroundings, materially affect the brightness requirements that will produce optimum seeing conditions.

Industrial lighting

- Offices: 200 Footcandles \( \rightarrow \) cartography, designing
- 150 \( \rightarrow \) accounting
- 100 \( \rightarrow \) regular office work
- 30 \( \rightarrow \) reading high contrast or well-printed material task
Levels of illumination currently recommended

<table>
<thead>
<tr>
<th>Area</th>
<th>Footcandles on Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building construction</td>
<td>10</td>
</tr>
<tr>
<td>Excavation work</td>
<td>2</td>
</tr>
<tr>
<td>Building exteriors</td>
<td></td>
</tr>
<tr>
<td>Entrances: active (pedestrian)</td>
<td>5</td>
</tr>
<tr>
<td>Inactive (infrequently used)</td>
<td>1</td>
</tr>
<tr>
<td>Building surrounds</td>
<td>1</td>
</tr>
<tr>
<td>Service garages (repairs)</td>
<td>100</td>
</tr>
<tr>
<td>Active traffic areas</td>
<td>20</td>
</tr>
<tr>
<td>Traffic lanes</td>
<td>10</td>
</tr>
</tbody>
</table>

Levels of illumination currently recommended

<table>
<thead>
<tr>
<th>Area</th>
<th>Footcandles on Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine shops</td>
<td></td>
</tr>
<tr>
<td>rough bench and machine work</td>
<td>50</td>
</tr>
<tr>
<td>medium bench, rough grinding</td>
<td>100</td>
</tr>
<tr>
<td>fine bench, fine polishing</td>
<td>500</td>
</tr>
<tr>
<td>extra fine bench and fine work</td>
<td>1000</td>
</tr>
<tr>
<td>Material handling</td>
<td></td>
</tr>
<tr>
<td>wrapping, packing</td>
<td>50</td>
</tr>
<tr>
<td>Offices</td>
<td></td>
</tr>
<tr>
<td>cartography, designing</td>
<td>200</td>
</tr>
<tr>
<td>accounting, bookkeeping</td>
<td>150</td>
</tr>
<tr>
<td>regular office work</td>
<td>100</td>
</tr>
<tr>
<td>corridor, elevators, escalator</td>
<td>20</td>
</tr>
</tbody>
</table>

INFRA MERAH (1)
- Klasifikasi: 0,75 - 3000µ
  - near IM: 0,75 – 2,5µ
  - intermediate IM: 2,5 – 5,0µ
  - far IM: 5,0 – 300µ
  - extreme IM: 300 – 3000µ
- Sumber: benda yang dipanaskan, atom berotasi & bervibrasi → gelombang panas, Bila suhu dinaikkan → tampak cahaya
- Penggunaan di industri:
  - pengerengan, memanggang cat, vernis, enamel, adhesive, tinta printer, pelapis protektif
  - memanaskan metal, untuk proses: shrink fit, thermal aging, welding, menempelkan adhesive, radiation testing
  - dehidrasi tekstil, kertas, kutil, daging, sayuran, pottery, jamur
  - spot heating

INFRA MERAH (2)
- Mudah diabsorpsi oleh warna (muda atau tua) Mudah diserap oleh material berwarna tua (λ>2,5 µ) dan warna muda (λ: 0,75-9 µ)
- Efek: rasa hangat, panas pada kulit, intensitas tergantung pada λ, lama eksposur, dan energi IM
  - diabsorpsi sempurna oleh kulit: 5 -3000µ
  - luka bakar pada kulit, meningkatkan pigmentasi: 0,75 - 15µ
  - kerusakan kornea, lensa, iris, retina, dan menjadi katarak mata: λ << NAB:
  - kerusakan kornea: 0,4 – 0,8 W.dtk/cm² = 0,1-0,2 cal/cm²
  - NAB retina: 1/10 nab kornea

Effect of electromagnetic radiation on the eye

IR rays generally forewarn by a burning sensation that is felt immediately on viewing sources emitting intense infrared radiant energy.

In many industrial operations, there may not be sufficient IR energy to produce permanent injury; nevertheless, unwarranted risk should not be taken, since severe injury may result through continuous exposure for long periods of time to intensities that might not be recognized as dangerous.

Infrared Radiation (IR)

It is generally considered that the IR region of the electromagnetic spectrum extends from the visible red light region (0.75 microns), to the 3000 micron wavelength of microwaves.

Exposures to IR radiation can occur from any surface which is at a higher temperature than the receiver.

IR radiation may be used for any heating application where the principal product surfaces can be arranged for exposure to the heat sources.

Transfer of energy or heat occurs whenever radiant energy emitted by one body is absorbed by another.

The electromagnetic spectrum wavelengths longer than those of visible energy (0.75 microns) and shorter than those of radar waves are utilized for radiant heating.
**Infrared Radiation (IR)**

Water vapor and visible aerosols, such as steam, readily absorb the longer infrared wavelengths.

Typical industrial applications include:

(a) Drying and baking of paints, varnishes, printers’ ink, and other protective coatings;
(b) Heating of metal parts for shrink fit assembly, forming, thermal aging, brazing, radiation testing
(c) Dehydrating of textiles, paper, leather, meat, vegetables.
(d) Spot and localized heating for any desired objective.

IR is perceptible as a sensation of warmth on the skin. The increase in tissue temperature upon exposure to IR radiation depends upon the wavelength, the total amount of energy delivered to the tissue, and the length of exposure.

IR radiation in the far wavelength region of 5 to 3000 microns is completely absorbed in the surface layers of the skin. Exposure to IR radiation in the region between 0.75 to 1.5 microns can cause acute skin burn and increased persistent skin pigmentation.

This short wavelength region of the infrared is capable of causing injuries to the cornea, iris, retina, and lens of the eye. Excessive exposure of the eyes to luminous radiation, mainly visible and IR radiation, from furnaces and similar hot bodies has been said for many years to produce “heat cataract.”

**Microwave**

- **Source**
- **Purpose**
- **Danger effect**
- **Control**

**MICROWAVE & GEL. RADIO (1)**

- **Klasifikasi:** frekuensi 10-300.000 Mhz
- **Sumber:**
  - Antenna TV
  - Transmitter FM
  - Transmitter radar
- **Penggunaan:**
  - Oven microwave (915-2450 MHz)
  - Freeze drying
  - Glueing
- **Karakteristik:**
  - MW: kontinu, dapat diabsorpsi, direfleks, ditransmisikan
  - CW: intermiten=pulsed mode→High intensity

**MICROWAVE & GEL. RADIO (2)**

- **Efek:**
  - panas=dielektrik heating, suhu badan naik
  - bahaya bila λ panjang dan frekuensi rendah, ekposur lama → mudah menembus kulit dan menembus otot-otot
  - 3000 MHz: diabsorpsi kulit; 3000-1000MHz masuk ke jaringan lemak bawah kulit, <1000MHz masuk ke otot-otot, katarak, bahaya bagi gonads
Microwaves and radio waves

An intolerable rise in body temperature, as well as localized damage, can result from exposure to microwaves of sufficient intensity and time. In addition, flammable gases and vapors may ignite when they are inside metallic objects located within a microwave beam.

Power intensities for microwaves are given in units of watts per square centimeter. Areas having a power intensity of over 0.01 W/sq cm should be avoided.

The exact biologic effects of microwave radiation at low levels is not known. But indications are that overdoses at high power levels cause eye cataracts.

The generally accepted maximum permissible exposure limit is 10 milliwatts per square centimeter (mW/sq cm).

Microwaves and radio waves

Microwave energy, a very convenient source of heat, has clear advantages over other heat sources in certain applications. It is clean, flexible, and reacts instantly to control.

Microwave heating eliminates combustion products or convection heating from being added to the working environment.

The frequency selected for microwave cooking ovens tends to be either 915 or 2450 MHz.

In special circumstances the lower-frequency might well be favored because of greater penetration.