MEDICAL UNIVERSITY – PLEVEN
FACULTY OF MEDICINE

DIVISION OF PHYSICS AND BIOPHYSICS

LECTURE No1

MEDICAL PHYSICS. MEASUREMENT AND THE SCIENTIFIC METHOD OF INVESTIGATION

The role of the experiment. Measurement. Accuracy and significant digits. Scientific notation. The conversion of units

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What is Medical Physics?

Def. Medical physics is the application of physics to the diagnosis, treatment and prevention of human disease and disability.

The traditional areas of medical physics have been in radiotherapy, nuclear medicine and in health physics,

but with the recent rapid translation of new physical techniques into medical instrumentation, physics is becoming essential in many clinical areas, e.g. magnetic resonance imaging (MRI), ultrasound, measurement of the body's electric and magnetic fields, positron emission tomography, pulmonary physiology, cardiology, neurology, ophthalmology and biomedical sensors and implants.

The medical physicist is an important member of the medical team in any modern hospital facility.

Furthermore medical physicists are involved in the calibration, maintenance and use of various instruments and are often required to modify and improve instruments for research purposes.

There has also been an increasing demand for health physicists who are concerned with the environmental and occupational sources of health hazards. Their interest is not only in the safe use of ionizing radiation, but also in microwaves, sound and laser radiation.

THE STANDARD PREFIXES FOR UNITS

10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P

SIGNIFICANT FIGURES

1. All nonzero digits are significant:
   11 ^{0}C has two significant digits
   31.5 ^{0}C has three significant digits

2. Zeros between nonzero figures are significant:
   203.001 m has six significant digits

3. Zeros to the right of a nonzero figure, but to the left of an understood decimal point, are not significant unless specifically indicated to be significant:
   107 000 km contains three significant figures
   107 $\underline{0}$00 km contains five significant figures

SIGNIFICANT FIGURES

4. All zeros to the right of a decimal point but to the left of a nonzero figure are never significant:
   0.0001346 kg contains four significant figures

5. All zeros to the right of a decimal point and following a nonzero figure are significant: both 0.07080 cm and 20.00 cm have four significant figures.

6. Rule for addition and subtraction. Remember that the rightmost significant figure in a measurement is uncertain. The rightmost significant figure in a sum or difference will be determined by the leftmost place at which an uncertain figure occurs in any of the measurements being added or subtracted.

SIGNIFICANT FIGURES

7. Rule for multiplication and division. The number of significant figures of a multiplication or division of two or more quantities is equal to the smallest number of significant figures for the quantities involved. In other words, the product or quotient should not have more significant figures than the least precise factor.

8. Rule for rounding. If the first figure to be dropped in rounding off is 4 or less, the preceding is not changed; if it is 6 or more, the preceding figure is raised by 1. If the figure to be dropped in rounding off is a 5 followed by figures other than zeros, the preceding figure is raised by 1. If the figure to be dropped in rounding off are a 5 followed by zeros, the preceding figure is not changed if it is even; but if it is odd, it is raised by 1.

ACCURACY AND PRECISION

Each of the following conversions contains an error. In each case, explain what the error is.

a)

$$1000\,\text{kg} \times \frac{1\,\text{kg}}{100\,\text{g}} = 1\,\text{g}$$

b)

$$50\ \text{m} \times \frac{10\ \text{cm}}{100\ \text{m}} = 0.5\ \text{cm}$$

c) „Nano" is 10^{-9}, so there are 10^{-9} nm in a meter.

(d) „Micro" is 10^{-6}, so 1 kg is 10^{-6} µg.

Express each of the following quantities in micrograms:

(a) 10 mg (b) 10^4 g (c) 10 kg,

(d) 100×10^3 g (e) 1000 ng

The speed of light is 3.0×10^8 m/s.

Convert this to km/ms.

A rectangular object has measured dimensions of 3.7 cm and 10.5 cm. Calculate the area of the rectangle and express it with the appropriate number of significant digits.

The length, width, and height of a room are measured to be 7.1 m, 3.6 m, and 1.3 m, respectively. Each measurement is subject to a 1% error. Find the volume of the room and its uncertainty in cubic meters. Assume that the percentage errors add. Express the answer with the appropriate number of significant digits.

A bar of aluminum has measured dimensions of 4.4±0.2 cm, 5.1±0.3 cm, and 3.70±0.30 cm. Calculate the volume and express it with the correct number of significant digits. Calculate the uncertainty in the volume by summing the percentage errors of the individual measurements and write the volume with its uncertainty in cm^3.

What percentage error will there be in the area of a piece of cloth if its length and width are 1.3±0.1 m and 2.7 ±0.2 m?

Suppose the following series of measurements are made: 25, 23, 14, 19, 18. Find the mean value and, assuming that the uncertainty is the maximum deviation from the average, express the average with its uncertainty.

A tissue cross-section viewed on a microscope slide shows a cell of almost rectangular shape with dimensions 17.9×10^{-4} cm by 0.1×10^{-3} cm. Calculate the cross-sectional area of the cell. Express the area in powers of ten notation and use the appropriate number of significant digits for the number multiplying the power of 10.

Below each given number , write the same value in "powers of ten notation"

a) 123.0 b) 0.0000560

Give the results of the following calculations in standard SI units with powers of ten notation and correct number of significant figures

$(9.80\ m/s^2) \times (27\ ps) =$

$(3.3\ km/s) \times (67\ \mu s) =$

$(1.6\ m/s^2) \times (4.90\ kg) =$

$(980\ kg/m^3) \times (2.44\ cm^3) =$