



**The Abdus Salam
International Centre for Theoretical Physics**



2166-Handout

**College on Medical Physics. Digital Imaging Science and Technology to
Enhance Healthcare in the Developing Countries**

13 September - 1 October, 2010

e-Learning in Medical Physics and EMITEL e-Encyclopaedia with Dictionary

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*King's College London
United Kingdom*



EMITEL e-Encyclopaedia of Medical Physics and Multilingual Dictionary of Terms



ENCYCLOPEDIA DICTIONARY COMBINED Project Contributors User Guide Copyright Disclaimer

e-Learning in Medical Physics and EMITEL e-Encyclopaedia with Dictionary

S Tabakov, EMITEL Consortium

King's College London; International Organization for Medical Physics (IOMP); University of Florence; University of Lund; Lund University Hospital; King's College Hospital; AM Studio, EMITEL Network of 270+ specialists (for contact: slavik.tabakov@emerald2.co.uk)



The delivery of contemporary healthcare is impossible without medical technology - one of the most advanced technologies of our time.



Education and Training in the field is complex, demanding and difficult to organise.

1. The biggest e-L advantage is the easy explanation of contemporary science. Adding computer simulations, interactive diagrams or just digital images increases enormously the effectiveness of teaching.



2. The easy upgrade of e-L materials is additional advantage, imperative for dynamic profession as Medical Physics and Engineering.



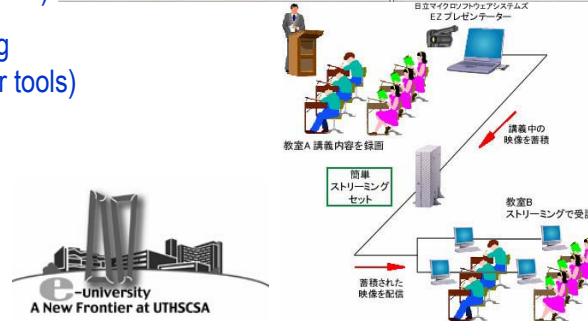
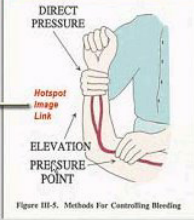
Effectiveness of learning

- Pedagogical effectiveness
(better learning)

- Economic efficiency
(more students per teacher)

Management of learning
(administrator+assessor tools)

Method	Procedures	Examples
Direct local pressure	<ul style="list-style-type: none"> Place direct pressure, pad over the wound and press firmly Wrap firmly with pressure bandage 	
Elevation	<ul style="list-style-type: none"> Elevate the wound above the level of the heart 	
Pressure Points	<ul style="list-style-type: none"> Femoral point for leg bleeding Brachial point for arm bleeding Others 	
Tourniquet	<ul style="list-style-type: none"> Only as a last resort 	



Main e-Learning layers:

-Building simulations

-Developing modules

-Structuring programs

e-learning production:

- field knowledge

- paedagogical approach

- e-developer

http://www.sprawls.org/resources/RADQU/

SPRAWLS EDUCATIONAL FOUNDATION The Physical Principles of Medical Imaging Online

Radiation Quantities and Units
Perry Sprawls, Ph.D.

Introduction and Overview

http://www.sprawls.org/ppm2/BLUR/

SPRAWLS EDUCATIONAL FOUNDATION
Open Resources for Learning and Teaching
The Physical Principles of Medical Imaging

Blur, Resolution, and Visibility of Detail
Perry Sprawls, Ph.D.

Online Textbook
Table of Contents

CHAPTER CONTENTS

- INTRODUCTION AND OVERVIEW
- BLUR
 - Blur Size
 - Blur Shape
 - Blur Profile
- VISIBILITY OF DETAIL
- UNSHARPNESS
- RESOLUTION
 - Limiting Resolution
 - Comparing The Imaging Modalities
- MODULATION TRANSFER FUNCTION
 - Spatial Frequency of Anatomical Objects
 - Composite MTF

[www.sprawls.org resources](http://www.sprawls.org/resources)

INTRODUCTION AND OVERVIEW **CONTENTS**

An important characteristic of any medical imaging method is its ability to show the anatomical detail of the human body. Detail, as used here, refers to the small structures, features, and objects associated with normal anatomy and various pathological conditions. The smallest detail that can be visualized is determined, to a large extent, by the amount of blur produced by the imaging procedure. There is some blur in

IPEM – X-ray Spectrum processing tool (independent)

Spectrum Details

Target Material: Tungsten (W)
Tube Voltage: 100 kVp
Anode Angle: 12 deg
Voltage Ripple: 0.2%
Source Filament: 000120 spc

Materials Used to Attenuate Spectrum

Material Name	Thickness / mm
Aluminum	3.35

Processed Photon Spectrum

Y-Axis Scale: Linear / Log 10

Energy / keV	Photons per (A.u. x mm ²)
0.5	0.789E+00
1.0	1.470E+00
1.5	2.080E+00
2.0	2.690E+00
2.5	3.300E+00
3.0	3.910E+00
3.5	4.520E+00
4.0	5.130E+00
4.5	5.740E+00
5.0	6.350E+00

Analysis of Processed Spectrum

Mean Photon Energy: 44.8 keV
Air Kerma: 1.258E+02 pCi per mAs at 1 m (W): 3.247E+03 mm Al

EMIT – MRI simulation (requires IDL Virtual machine)

Diffusion-DEMO:

Select first image:
Advanced loading
View images
View toolbar
Preferences
Tools

Advanced Image of Image

Inverse: 1004 dcm
Size: 128
Handler: DICOM
Queue: Yes

Set threshold in B0 image: 106
Default path: C:\EMERALD_end_EMIT e
Select option: **

Data files in directory:

- 1001 dcm
- 1002 dcm
- 1003 dcm
- 1004 dcm
- 1005 dcm
- 1006 dcm
- 1007 dcm
- 1008 dcm
- 1009 dcm
- 1010 dcm
- 1011 dcm
- 1012 dcm
- 1013 dcm
- 1014 dcm
- 1015 dcm
- 1016 dcm
- 1017 dcm
- 1018 dcm
- 1019 dcm
- 1020 dcm

Change grayscale
Auto loading
Number of slices: 6
select first image: 1004 dcm
select gradient: Gradient.M
View each loaded images for 0 Sec

LOADIT

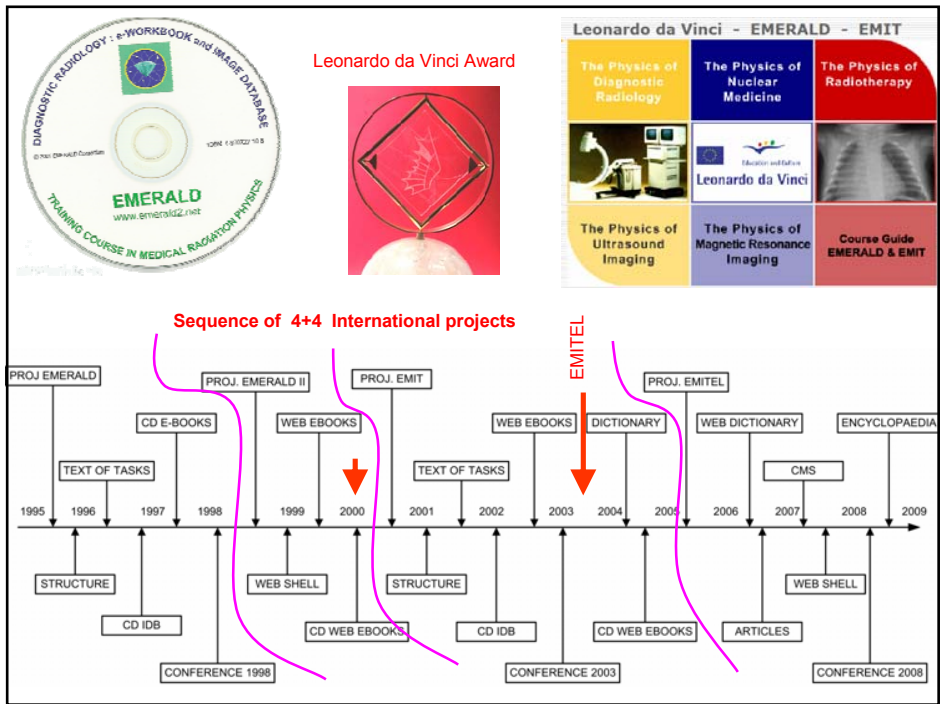
Done Help

Tables Options Function

Stretch Bottom: 21
Stretch Top: 1.00000

Gamma Correction:

- GRAYLINEAR
- BLUEWHITE
- GRN-RED-BLU-WHT
- RED-TEMPERATURE
- BLUE(GREEN-RED)/YELLOW
- STD GAMMA-II
- PRISM
- RED-PURPLE
- GREEN/WHITE LINEAR
- GRN/WHIT EXPONENTIAL
- GREEN-PINK
- BLUE-RED
- 16-LEVEL
- RAINBOW
- STEPS
- STERN-SPECIAL



EMERALD and EMIT modules (5 volumes)

Text hyperlinked with images + Educational Image Database + Timetables (training)

www.emerald2.eu

5.3 ASSESSMENT OF X-RAY TUBE OUTPUT PARAMETERS

5.3.1 Task

Assessment of X-ray Tube Output Consistency; Output variation with mA and with kV; Linearity. Assessment of the Focal spot size and the X-ray/Light beam alignment.

Approximate time for performing the task - 2 days.

Image Database functions

DiagRad.IDB in ThumbsPlus

File Edit Tree Picture Thumbnail Options Window Help

c:\ImgTDB
 95
 a\Centre
 A\Iichna
 A\proj
 Acrobat3
 Ati
 Backup
 Ban_cli
 bin
 Book
 Book1
 Bulletin
 Cdrom
 Cod9
 Dell
 DellUtil
 Deskscan
 Diagrad
 DiagRad
 @Index'
 D01
 D02
 D03
 D04
 D05
 D06
 D07
 D08
 D09
 DiagRadCDR
 DR\Edited99

D855 630x600x24(RGB)	D858 625x545x24(RGB)	D860 422x645x8(Gray)
D856 539x531x24(RGB)	D859 600x540x24(RGB)	D861 420x640x8(Gray)
D857 512x512x24(RGB)	D86 768x512x24(RGB)	D862 470x676x24(RGB)

Browsing
 Keywords
 Image Info
 Annotations
 Sorting
 Visualisation (full image quality)
 Image organisation follows workbook

Select Filter

Category: Charpen

Filter:

- Directional Sharpen
- Enhance Edges
- Sharpen
- Sharpen Less
- Sharpen More

Apply to:

- Intensity
- All channels
- Red
- Green
- Blue

Color Adjustment

Bright Hue Balance Gamma

Bright: +0

Contrast: +0

Auto view

Clear OK

Last Cancel

View Help

Copy > paste etc..

us01301

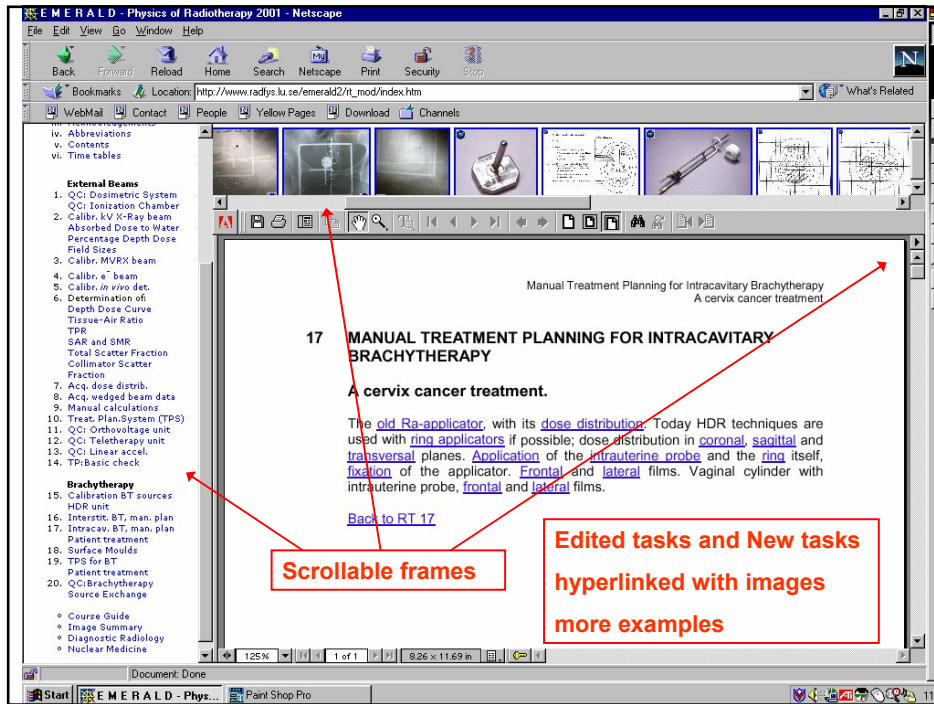
File Edit Image View Help

ThumbsCD1

Linear array Curved linear array Phased array

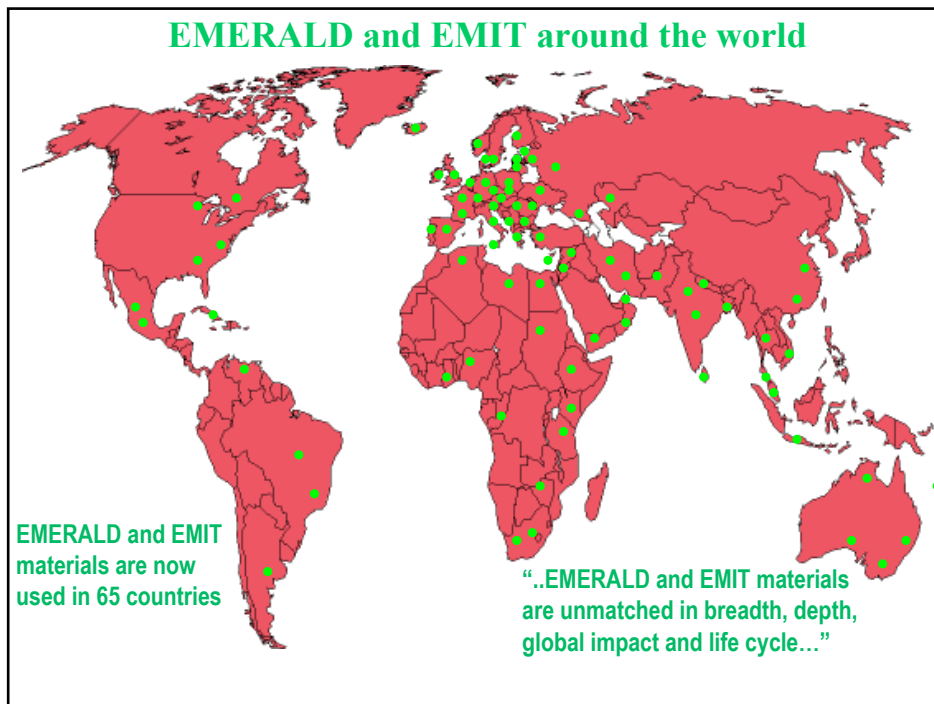
MOD Fit: 762x380x24,849.1Kb 0.6s @ 341,352 (255,255,255)

Image resolution
 normally up to 800 horiz. px.
 24 bits JPEG
Image Manipulation
 Contrast
 Brightness
 Gamma
 Filtering
 Colour depth
 Zoom +/-
 Captions



Scrollable frames

Edited tasks and New tasks hyperlinked with images more examples



European Medical Imaging Technology
e-Encyclopaedia for Lifelong Learning (EMITEL)

EMITEL Encyclopaedia of Medical Physics



The encyclopaedic articles cover:

- Diagnostic Radiology (X-ray)
- Nuclear Medicine
- Radiotherapy
- Ultrasound imaging
- MR imaging
- Radiation Protection



It is planned to extend to other areas of medical physics in the future.

Funding and support:

- Partially funded by the European Union under Leonardo da Vinci Programme
- International Contribution from key professionals
- All previous EMERALD and EMIT project materials included

Project Partners: King's College London and King's College Hospital (UK), University of Lund and Lund University Hospital (Sweden), University of Florence (Italy) and AM Studio, Plovdiv (Bulgaria), IOMP as an international partner, ICTP as supporting partner (Conference 2003).

EMITEL CONCEPTS:

- Filling an educational gap
- Educational value – first priority
- Reliable reference tool
- Allows easy update of the materials
- Minimum learning curve
- Maximum life cycle of the product
- Includes imaging material, diagrams and examples
- Use of simple software without compromising the content
- Useful for a broad audience of colleagues (use of dictionary)
- EU + International collaboration through IOMP
- Supported both for on-line and off-line use

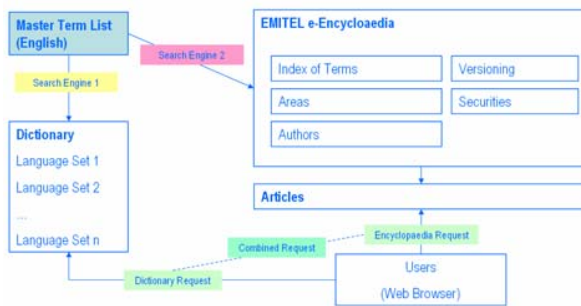


RESULTS Languages in the DICTIONARY:

Dictionary – 27 languages (in 8 alphabets), each with ~3400 terms:

English, French, German, Italian, Swedish, Spanish, Portuguese, Bulgarian, Czech, Greek, Hungarian, Lithuanian, Polish; Estonian, Romanian, Turkish, Latvian, Russian, Thai, Arabic, Persian, Bengal, Slovenian, Malay, Chinese, Japanese, Croatian

WEB DATABASE



Linear dose response curve	linjär dosresponskurva
Linear nonthreshold dose response	linjär dosrespons utan tröskel
Linear-quadratic dose-response curve	linjär-kvadratisk dosresponskurva
Maximum dose	maximum dos
Maximum permissible dose (MPD)	Maximal tillåten dos (MDP)
Maximum target dose	maximal target dos
Mean absorbed dose to air	medelabsorberad dos till luft
Mean lethal dose	Medeldos för dödlighet
Mean target absorbed dose	medeltargetdos

DICTIONARY (Translator)

Available both at: www.emitdictionary.co.uk and with the Encyclopaedia

Gratefully acknowledged contributors (details at www.emitel2.eu) :

Dictionary: Slavik Tabakov (Coordinator); Farida Bentayeb; Rachida El Meliani; Nagi Hussein; Ibrahim Elyasseery; Golam Abu Zakaria; Hasin Azhari Anupama; Md Akhtaruzzaman; Safayet Zaman; Jenia Vassileva; Venceslav Todorov; Petar Trindev; Slavik Tabakov; Borislav Konstantinov; Anastas Litchev; Andy Zhu; Dai Liyan; Dai Xiangkun; Fu Guishan; Geng Hui; Wang Jianhua; Wang Yunlai; He Zhengzhong; Xu Xiao; Xu Zhiyong; Yin Yong; Zhang Jiutang; Zhang Yue; Ivana Horakova; Anna Kindlova; Simona Trampotova; Daniela Kotalova; Vaclav Husak; Jaroslav Ptacek; Josef Pacholik; Pavel Dvorak; Libor Judas; Irena Novotna; Kalle Kepler; Sigrid Kivimae; Kalju Meigas; Juri Vedru; Alain Noel; Jean-Yves Giraud; Helene Bouscayrol; Louis Blache; Markus Buchgeister; Gunther Helms; Stefan Delorme; Stelios Christofides; Prodromos Kaplanis; George Christodoulides; Charalambos Yiannakkaras; Nicolaos Papadopoulos; Demetrios Kaolis; Georgiana Kokona; Georgios Menikou; Christos Papaefstathiou; Yiannis Gerogiannis; Demetra Constantinou; Spyros Spyrou; Andreas Mikelides; Anastasia Sissou; Christodoulos Christodoulou; Pal Zarand; Istvan Polgar; Tamas Porubszky; Janos Martos; Geza Safrany; Tamas Daboczi; Jozsef Varga; Franco Milano; Yuri Dekhtyar; Alexei Katashev; Marite Chaikovska; Emzinsh Dzintars; Sergei Popov; Lada Bumbure; Juris Rauzins; Plaude Sandija; Arunas Lukosevicius; Algidas Basevicius; Dovile Serenaitė; Diana Adliene; David Bradley; Alireza Binesh; Ali Asghar Mowlavi; Azam Niroomand-Rad; Marta Wasilewska-Radwanska; Zenon Matuszak; Katarzyna Matusiak; Aleksandra Jung; Ana Pascoal; Nuno Teixeira; Paulo Ferreira; Nuno Machado; Daniela Andrei; Cristina Petriou; Aurel Popescu; Octavian Dului; Raducu Popa; Constantin Milu; Valery Kostylev; Nina Lutova; Boris Narkevich; Tatiana Ratner; Ervin Podgorsak; Bozidar Casar; Vili Kovac; Damijan Skrk; Petra Tomse; Ana Millan; Ignacio Hernando; Alejandro García Romero; Inger-Lena Lamm; Monica Almqvist; Ronnie Wirestam; Sven-Erik Strand; Bo-Anders Jonsson; Michael Ljungberg; Freddy Stahlberg; Thomas Jansson; Anchali Krisanachinda; Sivalee Suriyapee; Tanawat Sontrapornpol; Panya Pasawang; Chotika Jumpangern; Taweap Sanghangthum; Isra Na Ayuthaya; Somjarod Oonsiri; Perihan Unak; Turgay Karali; Serap Teksoz; Zumurut Biber Muftuler; Fatma Yurt Lambrecht.

RESULTS Web Software: WWW.EMITEL2.EU

Web site – Database + Encyclopaedia web site with 2 Search engines (fully open)

Three modes: Encyclopaedia / Dictionary / Combined

Tested to work with all major Internet browsers

Materials tested by project members and by MSc students

EMITEL e-Encyclopaedia of Medical Physics and Multilingual Dictionary of Terms

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Choose Input Language: English Output Language: Latvian

Anode Translate

Anode	anods	General Diagnostic Radiology
Anode acceleration	Paātrināšana ar anodu	Diagnostic Radiology
Anode angle	anoda leņķis	Diagnostic Radiology
Anode heel effect	anoda sānsveres efekts	Diagnostic Radiology
Anode rotational speed	anoda rotācijas ātrums	Diagnostic Radiology

Anode heel effect
Diagnostic Radiology

The X-ray anode generates radiation in all directions (only a fraction of it is at the direction of the patient). The intensity of the radiation beam towards the patient has significant spatial variation. Figure 1 (curve 1) presents an example where the maximal intensity of a new X-ray tube (marked with 100%) is at direction 150 measured from the anode surface (this depends on the type of the X-ray tube). There is a notable loss of X-ray beam intensity (up to 50%) at the anode side of the beam. This is due to lesser production of X-ray photons at this direction (mainly due to absorption of the X-rays in the anode itself at the lower end of the target surface). This decreased intensity of radiation at the Anode site of the beam (if one looks it from the place of the patient) is known as "Heel effect".

RESULTS Articles (Encyclopaedic entries) :

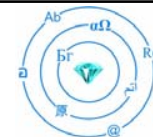
Completed c. 3400 articles - with c. 2500 images and diagrams

Volume approx. 2100 A4 pages (size of articles varies, median 300 words)

Language: English

Largest Work Pack – developed by 7 Groups working in parallel
Diagnostic Radiology (X-ray); Nuclear Medicine; Radiotherapy;
Ultrasound imaging; MR imaging; Radiation Protection; General

- Includes: synonyms, acronyms and abbreviations;
- Some articles written by 2 parallel Groups;
- Articles' content and use tested (by experts and students);
- System for editing and updating applied to each article;
- Search for part of the word (in case of misspelling)

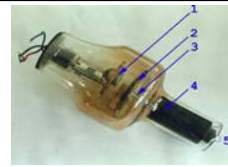


Types of articles:

1. Very Short (not many) - example

Unsharpness

Unsharpness is a characteristic of an image resulting from blurring. In such an image structures, objects, and edges appear to be "unsharp".



2. Short articles (often related to other articles) - example

Line focus principle

The line focus principle, first described by Dr. O. Goetze, in 1918, is found in most x-ray tubes. The usual cathode consists of a helical heated filament mounted in a focusing electrode. The resulting electron beam focused on the anode surface forms a focal spot that is an image of the elongated (line shaped) heated filament. The length is generally the largest dimension of the focal spot and is highly dependent on the angle of the anode surface and the direction from which the focal spot is being observed. *For more information see article on Stationary anode.*

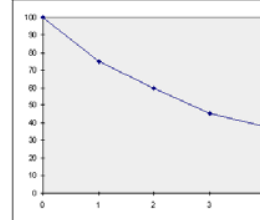
3. Typical articles (majority)

200-400 words plus one diagram or image

4. Very long articles (not many)

3-4 pages with 4-6 diagrams/images

5. Internally linked (no text at all) < 10%



Full text search - (inside article text in English – only in Encyclopaedia mode)

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attenuat Search

Search in: Title Full Text

Area: All

- Block transmission factor Radiotherapy
- Diamond detector Radiation Protection
- Secondary collimator Radiotherapy
- Treatment head Radiotherapy
- Multileaf collimator Radiotherapy
- Time-distance-shielding (TDS) rules Radiation Protection
- Neutron therapy Radiotherapy
- Grid efficiency Diagnostic Radiology
- MRI (Magnetic Resonance Imaging) Magnetic Resonance Imaging
- Flat panel detector Diagnostic Radiology
- Apparent diffusion coefficient (ADC) Magnetic Resonance Imaging
- Image artefact Ultrasound Imaging

Grid efficiency

Diagnostic Radiology

Grid efficiency is the combination of two factors. One is the ability to attenuate scattered radiation, which is its purpose, and the other is the undesirable attenuation of the primary radiation. Both of these are related to several factors but the predominant factor affecting grid efficiency is grid ratio as illustrated on Figure 1.

Figure 1. Illustration of Grid efficiency

Grid ratio (usually with values from 5:1 to 16:1) is a ratio between height (thickness) of the strips and width of the interspace. In general, the efficiency of a grid increases with grid ratio because the attenuation of the scattered radiation increases more than the attenuation of the primary

ENCYCLOPAEDIA

Gratefully acknowledged contributors (details at www.emitel2.eu) :



Encyclopaedia: Slavik Tabakov (Coordinator); Perry Sprawls; Graeme Taylor; Maria Lewis; Elizabeth Morris; Magdalena Stoeva; Asen Cvetkov; Mario Dedenaro; Niko-las Pallikarakis; Kalle Kepler; George D Frey; William Hendee; Ratko Magjarevic; Vassilka Tabakova; Alain Noel; Paola Bregant; Justine Calvert; Tracy Underwood; Stephen Wastling; Michelle Footman; Hannu Escolá; James Clinch; Hamish Richardson; Navneet Dulai; Sven-Erik Strand; Bo-Anders Jonsson; Mikael Peterson; Michael Ljungberg; Gillian Clarke; George Mawko; Anchali Krisanachinda; David Bradley; Ana Millan; Franco Milano; Inger-Lena Lamm; Fridtjof Nuesslin; Phil Evans; Charles Deehan; Joan Coward; Mark Grattan; Brendan McClean; Ruth McLauch-ian; Paul Zarand; Barry Allen; Markus Buchgeister; Ivana Horakova; Ervin Podgorsak; Jean-Yves Giraud; Freddy Stahlberg; Ronnie Wirestam; Andy Simmons; Stephen Keevil; Gerard Boyle; Nicola Harris; Emil Nordh; Adnan Bibic; Anders Nilsson; Anna Rydhog; Jimmy Latt; Johan Olsrud; Linda Knutsson; Peter Mannfolk; Sarah Brockstedt; Jonathan Siikanen; Mattias Nickel; Karlin Bloch; Markus Nilsson; Martin Leach; Mario Secca; Tobias Schaeffter; Ewald Moser; Gunter Helms; Jacques Bittoun; Cornelius Lewis; Jim Thurston; Peter Smith; Elizabeth Chaloner; Marta Radwanska; Anna Benini; Stelios Christophides; Cari Borrás; Kjeld Olsen; David Platten; Ignacio Hernando; Bruce Walmsley; Colin Deane; David Goss; Tomas Jansson; Monica Almqvist; Victoria Aitken; Lorna Sweetman; Fernando Schlindwein; Crispian Oates; Tony Evans; Heikki Terio; Luciano Bertocchi; Colin Roberts.



Dedicated Content Management System (CMS) for upload to the Database

CMS web site for regular updates and editing of content (open for Editorial Board)

The screenshot shows a web interface for a Content Management System (CMS). On the left, there is a navigation menu with options like 'User Account Details', 'Browse Terms', 'Documents', 'Help', and 'Logout'. The main content area displays a list of articles under the heading 'Echocardiography'. The article 'Echocardiography' is highlighted, showing its title, a 'Clinical' category, and a brief description: 'Echocardiography refers to the ultrasound examination of the heart. The echocardiogram gives information as to the structure and motion of the heart and the blood flow within it. The typical cardiac examination may use many of ultrasound's modalities, m-mode (Figure 1), b-mode, 3D, colour flow and pulsed and continuous wave spectral Doppler. The examination includes the pericardium (the tissue surrounding the heart), the structure of the heart including the chambers and valves and the velocity of blood flow in the heart.' Below the text are two small images: one showing an ultrasound scan and another showing a person's chest with an ultrasound probe. At the bottom of the article list, there are 'Create Article' links for each entry.

Included in 2010 through CMS – 2 languages and 100+ new and updated articles

EMITEL summary and future:

- The largest International project in the profession developed the first dedicated Medical Physics e-Encyclopaedia with Multilingual Dictionary

- Incremental build-up methodology (*iterations*):

Initial articles > Refereeing > Editing > Web publishing > Web update > Print

- Parallel Web update and paper print preparation (final pre-print editing by 2011)

- Web site will continue to be updated in future with the Network support

- Additional future international support (IOMP, IFMBE)

- Expanding the articles and including new articles and themes (CMS)

- Expanding EMITEL Network

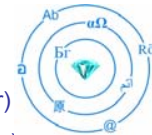


EMITEL International Network

- Objective: Regular update and support of EMITEL

- Coordination from King's College London (with dedicated administrator)

- Currently 250+ specialists from 35 countries (expected to grow in future)



All members are professional experts, the majority officers of their National Societies (of those 21 are Current and Past Presidents);

Many thanks to all supporters and contributors!



**European Medical Imaging Technology
e-Encyclopaedia for Lifelong Learning (EMITEL)**
Pilot Project of EU Leonardo da Vinci Programme



- Lack of a main information source point (reference material)
- A plethora of synonyms, acronyms and similar terms
- Lack of Multilingual professional dictionary



- This is the first dedicated e-Encyclopaedia in the profession
- Extremely large project (incremental build-up)
- Input from many international experts (also from MSc students)

ARTICLES (Encyclopaedic Entries) BUILD-UP AND PRESENTATION:

- Main objectives – high quality reference material with max. life cycle
- Guide for Contributors and Guide for Referees
- Master English file
- Template with easy to see font and layout
- Images in 2 resolutions (on the Web – colour; on paper mainly B/W)
- Limited references, but possibility for external web links
- Database – robust, updatable, fast and not complicated
- Two main layers – Article titles & Article text
- Articles internal connections – by Search Engines, not hyperlinks
- Web interface – modern design and user friendly
- Web Preview code independent on the web software platform
- Use of reliable Web server (large business provider)