TEACHING INSTRUCTIONAL DESIGN (BRP)

COURSE

Electromagnetic Fields 1

by

Prof. Dr. Anto Sulaksono, Dr. Cuk Imawan, Dr. Budhy Kurniawan

Undergraduate Program in Physics
Universitas Indonesia
Depok, December 2017

UNIVERSITAS INDONESIA
Faculty of Mathematics and Natural Sciences
Physics Undergraduate Study Program

TEACHING DESIGN BOOK

COURSE	Electromagnetic Fields 1	**Credit(s)**	**Prerequisite course(s)**	**Requisite for course(s)**	**Integration Between Other Courses**
COURSE CODE	SCPH60221	3	Basic Physics 2 Vibrations and Waves Mathematical Physics 2 Mathematical Physics 3	Electromagnetic Fields 2 Introduction to Nuclear Physics Spectroscopy 1	None
Course Cluster	COMPULSORY COURSE				
Semester	4				
Lecturer(s)	Dr. Cuk Imawan Dr. Budhy Kurniawan Prof. Dr. Anto Sulaksono				
Course Description	Electromagnetic Field 1 is a course about electricity and magnetism in advanced level compared to Electricity and Magnetism course. The content of this course consists of: definition of electrostatic, solution of electrostatic problem, static electric field at conductor and dielectric media, electrostatic energy, electric current, static magnetic field, steady-state current, magnetic properties of materials, magnetic energy, electromagnetic induction.				

LO-STUDY PROGRAM charged to the course	
CLO-1	Applying classical and modern physics concepts in solving general physics problems.

CLO-2	Formulate problems and solutions in Physics and its applications, as well as interdisciplinary problems related to science and mathematics in a critical, creative, and innovative way.
CLO-3	Summarizes basic knowledge in the fields of science and technology.
Course Learning Outcomes (CLO)	
CLO	Students are competent in solving static electric fields and magnetic fields problems, and are able to interpret the phenomena related to the concepts of static electricity and static magnetism as well as applying its applications in the fields of solids, materials, nuclear and particles, instrumentation, and medicine appropriately according to the applicable laws of physics (C3) .
Sub-CLOs	
Sub-CLO 1	Mampu menjelaskan konsep muatan listrik statik menghasilkan medan listrik statik dan muatan yang bergerak secara stasioner (arus stasioner) menghasilkan medan magnet statik dan mampu menjelaskan konsekuensi fisisnya (C3).
Sub-CLO 2	Mampu menghitung medan listrik dan medan magnet statik dari distribusi muatan statik dan distribusi arus stasioner dan interaksi antara distribusi kerapatan muatan dan kerapatan arus stasioner dengan medan luar (C3).
Sub-CLO 3	Mampu menjelaskan konsep energi elektrostatik dari distribusi muatan dan energi magnetostatik dari distribusi arus stasioner (C3).
Sub-CLO 4	Competent in applying Laplace's equation and Poisson’s equation for applying electrostatic and magnetostatic (C3).
Sub-CLO 5	Mampu mengaplikasikan konsep medan listrik statis di medium (dielektrik) dan konsep magnet statis pada bahan magnetik (C3).
Sub-CLO 6	Mampu menjelaskan konsep medan listrik dan magnet bervariasi lambat di vakum (C3).

Lesson: Lesson Materials	1. Electric charge, static electric field, and their physical consequences 2. Electric currents, static magnetic fields, and their physical consequences 3. Multipole moment of charge distribution and stationary current distribution 4. Interaction of electric dipole moment and magnetic dipole moment with external field and its extension 5. Electrostatic energy from the static charge distribution 6. Magnetostatic energy of stationary current distribution 7. Solving the Laplace equation for some essential cases using the variable separation method 8. The concept of an image charge to determine the Green function from the solution of the Poisson equation and solve the Poisson equation for some essential cases 9. Static electric field of dielectric medium, macroscopic and classical microscopic approximation 10. Static magnetic field of magnetic medium, macroscopic and classical microscopic approximation 11. Magnetic induction (Faraday's law), Displacement currents in a vacuum, Maxwell's equations in a vacuum, and their physical consequences in brief.
References	**Required:** J. Vanderlinde, *Classical Electromagnetic Theory, 2nd Edition*, Kluwer Academics Publisher, 2005. **Additional:** 1. D. J. Griffiths, *Introduction to Electrodynamics, 3rd Edition*, Prentice Hall, 1999. 2. R. K. Wangness, *Elektromagnetic Fields*, *2nd Edition*, J. Wiley and Son, 1986.

LESSON PLAN

*Wk	Sub-CLO (Expected final competence)	Study Material (Learning materials) [Reference]	Study Method [Time Estimation]	Learning Experience Orientation; Exercise; Feedback	Outcome Indicator sub-CLO General Indicators; Special Indicators	Quality of application of sub-CLO in the Course
1.	sub-CLO 1- 6	Introduction, Lecture Contract	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive lecture) [50 minutes]	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:** Lecturers respond to discussions via	**General Indicators:** Students have an overview of the global scope and structure of lectures	10 %

				MS-TEAMS or use chat rooms via EMAS (20%)		
2	Sub-CLO 1	1. Static electric charge, 2. electric force, 3. static electric field, 4. Gauss's Law, 5. Electric scalar potential **[References]** Ch 1, Classical electromagnetic Theory, Vanderlinde. Ch 2.1-2.3, Introduction to Electrodynamics, Griffiths. Ch. 2-5. Electromagnetic Fileds, Wangness.	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive lecture) [50 minutes]	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:** Lecturers respond to discussions via MS-TEAMS or use chat rooms via EMAS (20%)	**General Indicators:** Competent in understanding the properties of static electric fields and its physical consequences **Special Indicators:** Competent in handling some calculation problems related to static electricity.	15 %

3	Sub-CLO 1	1. The charge moves stationary (stationary current), 2. magnetic force, 3. static magnetic field 4. Ampere's Law 5. Magnetic vector potential **[References]** Ch. 1, Classical electromagnetic Theory, Vanderlinde. Ch. 5, Introduction to Electrodynamics, Griffiths. Ch. 12-16. Electromagnetic Fields, Wangness.	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive lecture) [50 minutes]	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:** Lecturers respond to discussions via MS-TEAMS or use chat rooms via EMAS (20%)	**General Indicators:** Competent in understanding the properties of static magnetic fields and its physical consequences **Special Indicators:** Competent in handling some computational problems related to static magnets.	10 %
4	Sub-CLO 2	1. Charge distribution, 2. Current distribution, and 3. Multipole moment	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS	**General Indicators:** Understand the impact of differences in the distribution of static charge and stationary current on the properties of	15%

		[References] Ch. 2, Classical electromagnetic Theory, Vanderlinde. Ch. 3.4, 5.4.3 Introduction to Electrodynamics, Griffiths. Ch. 8,19. Electromagnetic Fileds, Wangness.	lecture) [50 minutes]	or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:** Lecturers respond to discussions via MS-TEAMS or use chat rooms via EMAS (20%)	electric and static magnetic fields **Special Indicators:** 1. Knowing the advantages of multipole expansion for practical purposes 2. Can calculate the static electromagnetic moment	
5	Sub-CLO 2	1. Interaction of electric dipole and external electric field 2. Interaction of magnetic dipole with external magnetic field 3. Potential energy **[References]** Ch. 2, Classical electromagnetic Theory, Vanderlinde.	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive lecture) [50 minutes]	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:**	**General Indicators:** Understand the different physical responses of each dipole moment to an external static field in general **Special Indicators:** Can handle some calculation problems related to this section.	10 %

		Ch. 8-4,19-3. Electromagnetic Fileds, Wangness.		Lecturers respond to discussions via MS-TEAMS or use chat rooms via EMAS (20%)		
6	Sub-CLO 3	1. The energy of the static charge distribution, 2. Conductor 3. capacitance coefficient, 4. force on the distribution of static charge **[References]** Ch. 4, Classical electromagnetic Theory, Vanderlinde. Ch. 2.4-2.5, Introduction to Electrodynamics, Griffiths. Ch. 7. Electromagnetic Fileds, Wangness.	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive lecture) [50 minutes]	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:** Lecturers respond to discussions via MS-TEAMS or use chat rooms via EMAS (20%)	**General Indicators:** Understand the concept of electrostatic energy, the concept of capacitance in a conductor system, and the force experienced by charge distribution **Special Indicators:** Competent in handling some calculation problems related to this section.	10 %

7	Sub-CLO 3	1. The energy of the stationary current distribution, 2. Inductance Coefficient, 3. Potential energy of current distribution **[References]** Ch. 4, Classical electromagnetic Theory, Vanderlinde. Ch. 7.2.4, Introduction to Electrodynamics, Griffiths. Ch. 18. Electromagnetic Fileds, Wangness.	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive lecture) [50 minutes]	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:** Lecturers respond to discussions via MS-TEAMS or use chat rooms via EMAS (20%)	**General Indicators:** Understand the concept of magnetostatic energy, the concept of inductance in magnetic systems, and the potential energy of current distribution **Special Indicators:** Competent in handling some calculation problems related to this section.	10 %
8	**Midterm Exam**					

9	Sub-CLO 4	1. Laplace's equation of scalar electric/magnetic potential, 2. Variable separation method, 3. The theory of uniqueness and necessary boundary conditions. 4. Two- and three-dimensional examples for some essential coordinates **[References]** Ch. 5, Classical electromagnetic Theory, Vanderlinde. Ch. 3.1, Introduction to Electrodynamics, Griffiths. Ch. 9,11-1-11-5. Electromagnetic Fileds, Wangness.	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive lecture) [50 minutes]	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:** Lecturers respond to discussions via MS-TEAMS or use chat rooms via EMAS (20%)	**General Indicators:** Understand how to use the Laplace's equations to solve problems in static electricity and magnetism. **Special Indicators:** Competent in handling some calculation problems related to this section.	15 %

10	Sub-CLO 4	1. Poisson's equation, 2. Method of image, 3. Green's function **[References]** Ch. 6, Classical electromagnetic Theory, Vanderlinde. Ch. 11-6. Electromagnetic Fileds, Wangness.	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive lecture) [50 minutes]	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:** Lecturers respond to discussions via MS-TEAMS or use chat rooms via EMAS (20%)	**General Indicators:** Understand how to use the Posson's equation and the method of image to handle problems in static electricity and magnetism. **Special Indicators:** Competent in handling some calculation problems related to this section.	10 %
11	Sub-CLO 5	1. Static electric field due to polarized dielectric 2. Magnetic induction field due to magnetized matter	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS	**General Indicators:** Understand the properties of dielectric and magnetic materials from a classical macroscopic perspective.	15 %

		[References] Ch. 7, Classical electromagnetic Theory, Vanderlinde. Ch. 4,6, Introduction to Electrodynamics, Griffiths. Ch. 10,20. Electromagnetic Fileds, Wangness.	lecture) [50 minutes]	or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:** Lecturers respond to discussions via MS-TEAMS or use chat rooms via EMAS (20%)	**Special Indicators:** Competent in handling some calculation problems related to this section.	
12	Sub-CLO 5	Classical microscopic properties of electric and magnetic in matter (polar and nonpolar, paramagnetic and diamagnetic molecules) **[References]** Ch. 7, Classical electromagnetic Theory, Vanderlinde.	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive lecture) [50 minutes]	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:**	**General Indicators:** Understand the properties of dielectric and magnetic materials from a microscopic classical standpoint. **Special Indicators:** Competent in handling some calculation problems related to this section.	10

		Ch. 4,6, Introduction to Electrodynamics, Griffiths. Ch. 10,20. Electromagnetic Fileds, Wangness.		Lecturers respond to discussions via MS-TEAMS or use chat rooms via EMAS (20%)		
13	Sub-CLO 5	1. Boundary conditions in electric and magnetic fields for dielectrics and magnetic materials 2. Static electricity and magnetism in linear media (application of the Laplace and Poisson press) **[References]** Ch. 7, Classical electromagnetic Theory, Vanderlinde. Ch.4,6, Introduction to Electrodynamics, Griffiths. Ch. 10,20. Electromagnetic Fileds, Wangness.	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive lecture) [50 minutes]	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:** Lecturers respond to discussions via MS-TEAMS or use chat rooms via EMAS (20%)	**General Indicators:** Competent in applying the Laplace and Poisson equations with boundary conditions to handle problems related to dielectric materials and magnetic materials. **Special Indicators:** Competent in handling some calculation problems related to this section.	10 %

14	Sub-CLO 6	1. Magnetic Induction 2. EMF and Ohm's Law 3. Faraday's Law, 4. Current Displacement **[References]** Ch. 3, Classical electromagnetic Theory, Vanderlinde. Ch. 7-1,7-2 Introduction to Electrodynamics, Griffiths. Ch. 17. Electromagnetic Fileds, Wangness.	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive lecture) [50 minutes]	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:** Lecturers respond to discussions via MS-TEAMS or use chat rooms via EMAS (20%)	**General Indicators:** Understand the concept of magnetic induction, EMF, Faraday's law and displacement current **Special Indicators:** Competent in handling some calculation problems related to this section.	10 %
15	Sub-CLO 6	1.Maxwell's Equation in a vacuum 2. Electromagnetic Potentials 3. Wave Equation in a vacuum	**Asynchronous**: Using EMAS (Self-study) [100 minutes] **Synchronous**: Using MS-TEAMS or EMAS chat (Interactive	**Orientation:** Students can view files, watch videos or use chat rooms via EMAS (30%) **Exercise:** Students discuss via MS-TEAMS	**General Indicators:** Understand the meaning of Maxwell's equations in vacuum and its consequences in the form of waves	10 %

		[References] Ch. 3, Classical electromagnetic Theory, Vanderlinde. Ch. 7-1,7-2 Introduction to Electrodynamics, Griffiths. Ch.. 17. Electromagnetic Fileds, Wangness	lecture) [50 minutes]	or use chat rooms via EMAS and study the literature on their own checking concepts that are not clear (50%) **Feedback:** Lecturers respond to discussions via MS-TEAMS or use chat rooms via EMAS (20%)	**Special Indicators:** Competent in handling some calculation problems related to this section.	
16	**Final Term Exam**					

*)Wk: Week

RANCANGAN TUGAS DAN LATIHAN

Week	Assignment Name	Sub-CLO	Assignment	Scope	Procedure	Deadline	Output
1.	Individual Assignment	Sub-CLO 1-6	Study of Literature	Review the basic materials and mathematics needed in the literature	At home (individual)	1 week	Report in the form of a short paper to upload it via EMAS
2.	Individual/Group Assignment	Sub-CLO 1	Writing Working Paper	The contents of the working paper contains a resume related to the topics discussed in sub-CLO 1	Group assignments discussion in EMAS chat room, and submission via online	Akhir tengah semester	Upload working paper via EMAS

3.	Individual Assignment	Sub-CLO 1	Answering Homework Problems	Electrostatic and magnetostatic	At home (individual)	1 week	Upload the answers in EMAS
4.	Individual/Group Assignment	Sub-CLO 2	Writing Working Paper	The contents of the working paper contains a resume related to the topics discussed in sub-CLO 2	Group assignments discussion in EMAS chat room, and submission via online	Akhir tengah semester	Upload working paper via EMAS
5.	Individual Assignment	Sub-CLO 2	Answering Homework Problems	Charge distribution and stationary current	At home (individual)	1 week	Upload the answers in EMAS

6	Individual/Group Assignment	Sub-CLO 3	Writing Working Paper	The contents of the working paper contains a resume related to the topics discussed in sub-CLO 3	Group assignments discussion in EMAS chat room, and submission via online	Akhir tengah semester	Upload working paper via EMAS
7	Individual Assigment	Sub-CLO 3	Answering Homework Problems	Electrostatic and Magnetostatic Energy	At home (individual)	1 week	Upload the answers in EMAS
8	**Midterm Exam**	**Sub-CLO 1-3**	**Answering Exam Problems**	**Sub-CLO 1-3 Materials**	**Online via EMAS**	**100 menit**	**Upload answers in EMAS**

9	Individual/Group Assignment	Sub-CLO 4	Writing Working Paper	The contents of the working paper contains a resume related to the topics discussed in sub-CLO 4	Group assignments discussion in EMAS chat room, and submission via online	Sebelum akhir semester	Upload working paper via EMAS
10	Individual Assignment	Sub-CLO 4	Answering Homework Problems	Laplace equation and Poisson equation	At home (individual)	1 week	Upload the answers in EMAS
11	Individual/Group Assignment	Sub-CLO 5	Writing Working Paper	The contents of the working paper contains a resume related to the topics discussed in sub-CLO 5	Group assignments discussion in EMAS chat room, and submission via online	Sebelum akhir semester	Upload working paper via EMAS

12.	Individual/Group Assignment	Sub-CLO 5	Answering Homework Problems	Electric Matter Properties	At home (individual)	1 week	Upload the answers in EMAS
13.	Individual Assignment	Sub-CLO 5	Answering Homework Problems	Magnetic Matter Properties and Answering Homework Problems	At home (individual)	1 week	Upload the answers in EMAS
14.	Individual/Group Assignment	Sub-CLO 6	Writing Working Paper	The contents of the working paper contains a resume related to the topics discussed in sub-CLO 6	Group assignments discussion in EMAS chat room, and submission via online	Sebelum akhir semester	Upload working paper via EMAS

15.	Individual Assignment	Sub-CLO 6	Answering Homework Problems	Electromagnetic fields vary slowly with respect to time	At home (individual)	1 week	Upload the answers in EMAS
16.	**Final Term Exam**	**Sub-CLO 4-6**	**Answering Exam Problems**	**Sub-CLO 4-6 Materials**	**Online via EMAS**	**100 minutes**	**Upload the answers in EMAS**

Assessment Criteria (Evaluation of Learning Outcomes)

Evaluation Type	Sub-CLO	Assessment Type	Frequency	Evaluation Weight (%)
Individual-Assignment	**Sub-CLO 1-6**	EMAS Assignment File	6	20
Group-Assignment	**Sub-CLO 1-6**	EMAS Assignment File	2	20
Mid-Term Exam	**Sub-CLO 1-3**	Online exam via EMAS	1	30
Final Exam	**Sub-CLO 4-6**	Online exam via EMAS	1	30
Total				**100**

Assessment Rubric:

Conversion of student final grades based on the applicable provisions at the University of Indonesia. The conversion grades are:

Score	Grade	Quality
85 — 100	A	4. 00
80 — < 85	A-	3. 70
75 — < 80	B +	3. 30
70 — < 75	B	3. 00
65 — < 70	B-	2. 70
60 — < 65	C +	2. 30
55 — < 60	C	2. 00
40 — < 50	D	1. 00
< 40	E	0.00

Example of a Working Paper Assessment Rubric:

Criteria	Score	Indicator
Preface	4	Contains: (1) background of report preparation, (2) problem identification/gap analysis, (3) questions (4) objectives, and (5) citing relevant and current references

	3	Contains the objective and 3 out of 4 other items
	2	Contains the objective and 2 out of 4 other items
	1	Does not contain the objectives of preparing the report, there is only one or more out of 4 other items
	0	Does not contain the objective as well as the other 4 items
Content	4	Structured & Cohesive, conducting a comprehensive literature review and conducting a complete critical analysis
	3	Structured, conduct a comprehensive literature review and perform a complete critical analysis
	2	Less structured, conducts a literature review but not comprehensive and only performs a simple critical analysis
	1	Unstructured & NOT Cohesive, literature review is not comprehensive and does not contain any critical analysis
Conclusion	4	Related to the task implementation and propose ideas (suggestions), that gives a feasible improvements for the next assignment
	3	Related to the task implementation and propose ideas (suggestions), that gives less feasible improvement for the next assignment
	2	Related to the task but does not offer any ideas (suggestions)
	1	Irrelevant to the task and does not offer any ideas (suggestions)
	4	Report is in order and interesting, attached with cover and photos/pictures
	3	Report is in order and interesting, attached with cover and photos/pictures
	2	Report is in order, attached with cover and photos/pictures but less interesting
	1	Report is less in order and less interesting, not attached with cover and photos/pictures
	4	Easy to understand, precise choice of words, and correct spelling
	3	Easy to understand, precise choice of words, and less correct spelling
	2	Less easy to understand, less precise choice of words, and some incorrect spelling
	1	Difficult to understand, incorrect choice of words, and incorrect spelling