<u>EEE349 – Power Engineering Electromagnetics</u>

Finite element analysis assignment sheet – December 2013

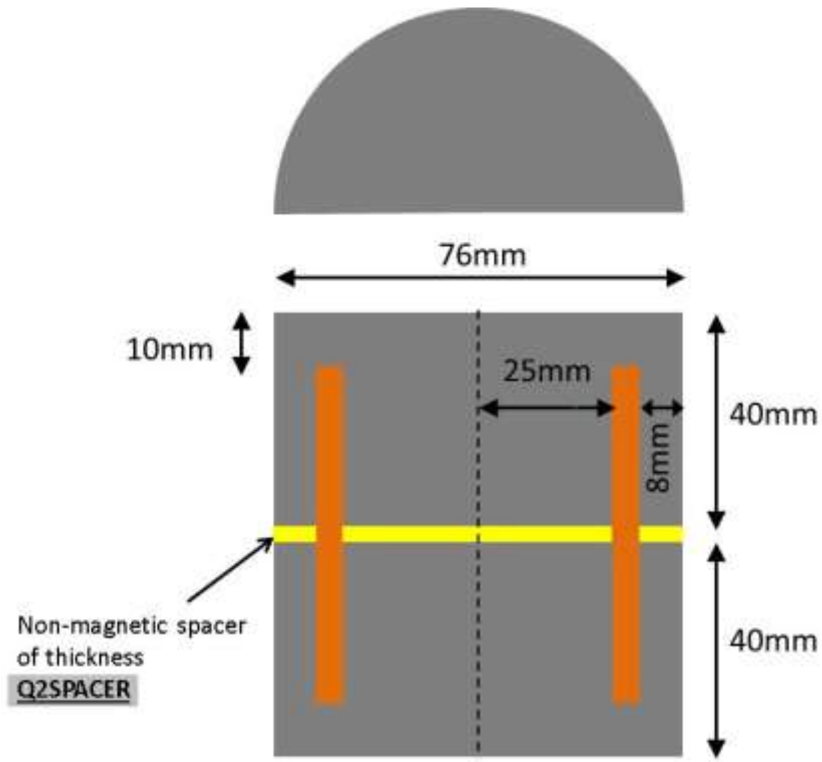
Each question contains a series of references to parameters (**<u>CAPITAL BOLD UNDERLINED AND HIGHLIGHTED IN GREY</u>**). Please consult Appendix A to get your individual values for these parameters. You should complete the assignment on the answer pro-forma supplied. You will also be required to submit your FEMM models electronically (full details of exact mechanism will be confirmed in January 2014). For questions 2 and 3 where you will reuse and modify the model several times you need only supply one version which, for example, could be for the last calculation you have completed.

A series of 10 minute individual viva sessions will be held in late March / April to check your understanding of the problems (timings are schedules will be available next semester to fit around lecturer commitments etc), The deadline for submission of your answer sheet and FEMM models is **<u>14/3/14</u>**

1 A 50Hz, **<u>Q1VOLT</u>** KVrms (line to line) three-phase , dual-circuit overhead transmission line is suspended between a series of **<u>Q1PYLON</u>** design pylons.
i) Calculate the ***maximum*** electrical field strength and magnetic field strength 1m above the ground if the system is delivering a power of **<u>Q1POWER</u>** MW at a power factor of **<u>Q1POWFAC</u>** lagging (this power is the total for both circuits on the pylon).
ii) Calculate the effective capacitance to ground of each of the three phases.
You can obtain pylon dimensions from:
http://www.emfs.info/Sources+of+EMFs/Overhead+power+lines/Calculating/geometries/

- You may assume that the two sides of the pylon are geometrically and electrically symmetrical.
- If some dimensions are not listed for your pylon and lines, then you may scale from the typical drawing of a representative pylon
- You may approximate the array of conductors which make up each line in practice (often 2 or 4) as a single conductor carrying the same overall current
- You should list any assumptions that you make regarding the location and time instant at which the maximum electric and magnetic field 1m above the ground is achieved
- List approximations that you make for pylon and line dimensions not fully specified in the National Grid data.

2. The figure below shows a cross-section through a cylindrical inductor which is to be used in a power electronic converter. The cylindrical symmetry of the inductor allows it to be modelled as an axisymmetric problem. This inductor is based on a so-called 'gapped core' in which a closely controlled airgap is introduced into the magnetic circuit by incorporating a non-magnetic spacer of a precise thickness **Q2-SPACER**. The upper and lower core regions are identical with an outer diameter of 76mm and a height of 40mm. The magnetic core is manufactured from **Q2MAT** (the B-H characteristic is listed in the FEMM material library). Each core incorporates a channel which is 30mm deep into which a cylindrical coil is fitted. The overall height of the coil is equal to the sum of the height of the two channels in the core and the thickness of the non-magnetic spacer.



i) By an iterative process, determine the coil region current density which results in a flux density of ~0.5T in the spacer at the centre of the inductor (i.e. at r=0mm)

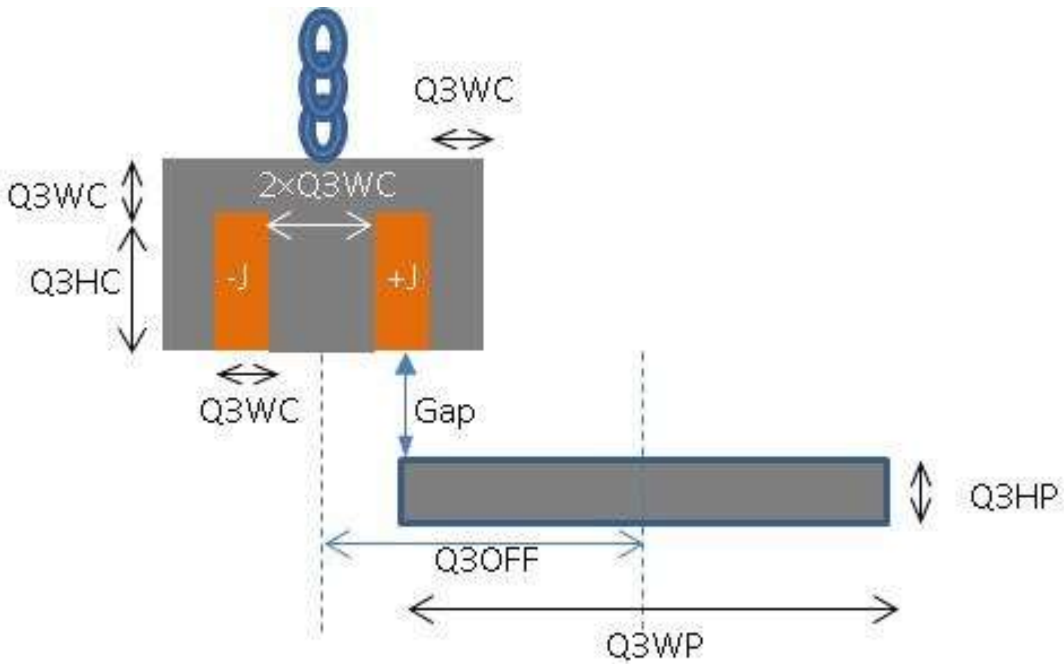
ii) Using the current density determined in part (i), calculate the inductance of the inductor.

iii) By increasing the current density in appropriate steps, find the current density at which the inductance is reduced to 80% of the value calculated in part (ii)

iv) The thickness of the spacer is doubled. Repeat the calculations of parts (i) (ii) and (iii) for this new space thickness.

v) Why might a thicker spacer be used in some applications?

3. The figure below shows a simplified representation of a magnetic fixture of the type used on cranes in scrap yards for lifting ferrous scrap. In the slightly simplified case shown, the magnetic lifting fixture is a simple soft magnetic E-core equipped with a single coil that has an effective current density through its cross-section of 4MA/m^2. The central pole of the E-core is twice the width of the side poles. It is used to lift a magnetic plate which is horizontally offset from the lifting fixture. Both the fixture and the plate can be assumed to be 1m long in the z-direction and the problem can be reasonably solved using a two-dimensional planar model. Using the appropriate combination of parameters listed in Appendix A, calculate the maximum value of the gap at which the ***vertical*** component of force on the plate just exceeds the gravitational force acting on it, i.e. it is likely to lift the plate. The lifting fixture core and the plate are made of 1006 Steel (B-H curve in FEMM material library) which has a density of 7800 kg/m^3.



Appendix A – Individual problem parameters

		Q1VOLT (kV rms)	Q1PYLON design	Q1POWER (MW)	Q1POWFAC all lagging	Q2SPACER (mm)	Q2MAT	Q3WC	Q3HC	Q3OFF	Q3HP	Q3WP
1	Dobrev	400	L6	400	0.8	0.40	Pure Iron	0.50m	0.53m	0.5m	0.20m	3.0m
2	Adeoye	400	L6	600	0.75	1.20	Pure Iron	0.50m	0.54m	0.6m	0.15m	3.2m
3	Adugu	400	L6	750	0.85	0.35	Pure Iron	0.50m	0.55m	0.7m	0.10m	2.8m
4	Aksit	400	L6	500	0.92	0.55	Pure Iron	0.50m	0.56m	0.8m	0.08m	2.6m
5	Akyigit	400	L6	820	0.9	1.00	Pure Iron	0.50m	0.57m	0.9m	0.12m	1.8m
6	Beswick	400	L6	540	0.91	0.85	Pure Iron	0.50m	0.52m	1.0m	0.14m	2.2m
7	Bin Ahmad Bostaman	400	L6	790	0.88	0.72	Pure Iron	0.50m	0.51m	1.1m	0.22m	2.5m
8	Constantinou	400	L6	910	0.82	0.95	Pure Iron	0.50m	0.50m	1.2m	0.11m	3.1m
9	Cooper	275	L6	275	0.85	0.30	Pure Iron	0.50m	0.59m	1.3m	0.24m	1.8m
10	Dexter	275	L6	300	0.9	0.40	Hiperco 50	0.65m	0.61m	0.5m	0.20m	2.2m
11	Emaki	275	L6	380	0.87	1.20	Hiperco 50	0.65m	0.62m	0.6m	0.15m	2.5m
12	Garlick	275	L6	360	0.86	0.35	Hiperco 50	0.65m	0.65m	0.7m	0.10m	3.0m
13	Gunsal	275	L6	420	0.86	0.50	Hiperco 50	0.65m	0.64m	0.8m	0.08m	3.2m
14	Hamzah	275	L6	460	0.83	1.00	Hiperco 50	0.65m	0.63m	0.9m	0.12m	2.8m
15	Heggie	275	L6	295	0.95	0.65	Hiperco 50	0.65m	0.69m	1.0m	0.14m	2.6m
16	Khalifa	400	L2	390	0.91	0.80	Hiperco 50	0.65m	0.68m	1.1m	0.22m	3.1m
17	Leonidou	400	L2	620	0.85	0.95	Hiperco 50	0.65m	0.67m	1.2m	0.11m	3.0m
18	Liebenberg Meyer	400	L2	710	0.94	0.30	Hiperco 50	0.65m	0.60m	1.3m	0.24m	3.2m
19	Lim	400	L2	490	0.86	0.45	Supermalloy	0.48m	0.52m	0.5m	0.20m	2.8m
20	Lonsdale	400	L2	780	0.81	1.20	Supermalloy	0.48m	0.53m	0.6m	0.15m	2.6m
21	Majul	400	L2	900	0.97	0.35	Supermalloy	0.48m	0.57m	0.7m	0.10m	3.1m
22	Mananga	400	L2	820	0.86	0.50	Supermalloy	0.48m	0.50m	0.8m	0.08m	2.6m
23	Owolabi	400	L2	790	0.87	1.00	Supermalloy	0.48m	0.54m	0.9m	0.12m	1.8m
24	Paraskeva	275	L2	305	0.82	0.65	Supermalloy	0.48m	0.60m	1.0m	0.14m	2.2m
25	Poyiatzis	275	L2	280	0.93	0.80	Supermalloy	0.48m	0.54m	1.1m	0.22m	2.5m

26	Qureshi	275	L2	395	0.89	0.95	Supermalloy	0.48m	0.53m	1.2m	0.11m	2.2m
27	Rastall	275	L2	400	0.87	0.30	Supermalloy	0.54m	0.52m	1.3m	0.24m	2.5m
28	Robinson	275	L2	380	0.85	1.40	1006 Steel	0.54m	0.63m	0.5m	0.20m	3.0m
29	Salehudin	275	L2	360	0.89	1.20	1006 Steel	0.54m	0.67m	0.6m	0.15m	3.2m
30	Shittu	275	L2	440	0.93	0.35	1006 Steel	0.54m	0.50m	0.7m	0.10m	2.8m
31	Siddharth	400	L12	400	0.91	0.50	1006 Steel	0.54m	0.54m	0.8m	0.08m	2.6m
32	Stevens	400	L12	600	0.9	1.00	1006 Steel	0.54m	0.60m	0.9m	0.12m	3.1m
33	Sun	400	L12	750	0.88	0.65	1006 Steel	0.54m	0.54m	1.0m	0.14m	3.0m
34	Uttamchandani Mirchandani	400	L12	500	0.83	0.80	1006 Steel	0.60m	0.53m	1.1m	0.22m	3.2m
35	Williams	400	L12	820	0.92	0.95	1006 Steel	0.60m	0.57m	1.2m	0.11m	3.2m
36	Xia	400	L12	710	0.87	0.30	1006 Steel	0.60m	0.50m	1.3m	0.24m	2.3m
37	Yiannakou	400	L12	905	0.86	0.42	M27-Steel	0.60m	0.54m	0.5m	0.20m	2.5m
38	Zhang - T	400	L12	650	0.82	0.95	M27-Steel	0.60m	0.60m	0.6m	0.15m	2.7m
39	Zhang - Y	275	L12	315	0.88	1.15	M27-Steel	0.60m	0.70m	0.7m	0.10m	3.0m
40	Zhou	275	L12	270	0.92	0.50	M27-Steel	0.60m	0.73m	0.8m	0.08m	3.1m
41	SPARE	275	L12	410	0.94	1.00	M27-Steel	0.62m	0.71m	0.9m	0.12m	2.8m
42	SPARE	275	L12	430	0.89	1.25	M27-Steel	0.62m	0.58m	1.0m	0.14m	2.6m
43	SPARE	275	L12	380	0.79	0.80	M27-Steel	0.62m	0.54m	1.1m	0.22m	3.1m
44	SPARE	275	L12	360	0.87	0.75	M27-Steel	0.62m	0.61m	1.2m	0.11m	3.0m
45	SPARE	275	L12	315	0.85	0.60	M27-Steel	0.62m	0.62m	1.3m	0.24m	3.2m