#### ECE 3318

#### Applied Electricity and Magnetism

**Final Exam**

#### May 10, 2022

Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**General Instructions**

1. This exam is open-book and open-notes.
2. Show all of your work. No credit will be given if the work required to obtain the solutions is not shown.
3. Write neatly. You will not be given credit for work that is not **easily** legible.
4. Leave answers in terms of the parameters given in the problem.
5. Show units in all of your final answers.
6. Circle your final answers.
7. Double-check your answers. For simpler problems, partial credit may not be given.
8. If you have any questions, ask the instructor. You will not be given credit for work that is based on a wrong assumption.

**TABLE OF INTEGRALS**

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Problem 1 (20 pts.)

A cylindrical power bus (tube) in a power substation runs next to a tall grounded metal wall as shown below. The radius of the power bus is *a*. The spacing between the center of the bus and the wall is denoted as *h*. The air has a dielectric breakdown field strength of *Ec* [V/m].

Derive a formula for the maximum voltage *V*max that can be put on the bus (with respect to ground) before corona discharge takes place on the bus.

You may use any formula from the class notes that you wish. Make sure your answer is as accurate as possible (do not neglect anything in your derivaiton).



ROOM FOR WORK

ROOM FOR WORK

Problem 2 (20 pts.)

A stepped leader is descending vertically down from the clouds. The stepped leader is descending halfway between two tall buildings, as shown below. Each building is 40 meters tall. The stepped leader will strike an object once the tip of the stepped leader is within 50 meters of any point on that object (due to the streamer coming from the object). A flagpole is located halfway between the two buildings, of height *h*. The two buildings are separated by a distance of 30 [m].

What is the maximum allowed height *h* of the flagpole, if we wish to be sure that the flagpole will not get struck by lightning?



ROOM FOR WORK

ROOM FOR WORK

Problem 3 (20 pts.)

A transmission line consists of a center metal slab surrounded by a top and bottom metal slab as shown below. All three slabs have the same thickness *h* and width *w*, and they are infinite in the *z* direction. The central slab carries a DC current *I* in the *z* direction. The top and bottom slabs each carry a DC current of *I*/2 in the negative *z* direction.

Find the magnetic field inside the central slab, for .

Assume that  so that you may neglect fringing. You may also assume that the current density inside each slab is uniform.



ROOM FOR WORK



ROOM FOR WORK

Problem 4 (20 pts.)

Find the magnetic field at the observation point on the *y* axis due to the wire shown below. The wire is infinite along the *x* and *z* axes, and carries a DC current of *I* Amps.



ROOM FOR WORK

ROOM FOR WORK

Problem 5 (20 pts.)

Two coils (coil 1 and coil 2) are wound on a square transformer core as shown below.

a) Find a formula for the self inductances  and .

b) Find a formula for the mutual inductance .

Use a magnetic circuit model to help you with this calculation.





ROOM FOR WORK

ROOM FOR WORK

BONUS PROBLEM (10 pts)

(1) What is the “rolling sphere” method, and how can it be used to predict if something is subject to being hit by lightning?

(2) Why it is important for a lightning rod to be well grounded?

ROOM FOR WORK