UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF APPLIED PHYSICS & ENGINEERING MATHEMATICS

NATIONAL DIPLOMA IN CHEMICAL ENGINEERING

MODULE PHY1BCT
ENGINEERING PHYSICS II

CAMPUS **DFC**

SUPPLEMENTARY EXAMINATION

DATE: 03 December 2015 **SESSION: 08:00 – 11:00**

ASSESSOR **Mr. T.G. Mathe**

INTERNAL MODERATOR **Dr. L. Reddy**

DURATION **3 HOURS** **MARKS** **140**

NUMBER OF PAGES: 9 PAGES, INCLUDING 2 ANNEXURE (DATA SHEET).

INSTRUCTIONS TO CANDIDATES:

- **ANSWER ALL THE QUESTIONS.**
- **KEEP ALL SUB-QUESTIONS TOGETHER.**
- **CALCULATORS ARE PERMITTED (ONLY ONE PER STUDENT).**
- **START EACH QUESTION ON A NEW PAGE.**
- **NUMERICAL ANSWERS ARE TO BE EXPRESSED IN SCIENTIFIC NOTATION & CORRECT NUMBER OF SIGNIFICANT FIGURES OBSERVED.**
- **WORK WRITTEN IN PENCIL WILL NOT BE MARKED. ONLY DRAWINGS ARE TO BE DONE IN PENCIL.**

REQUIREMENTS: ONE EXAMINATION ANSWER SCRIPTS PER STUDENT

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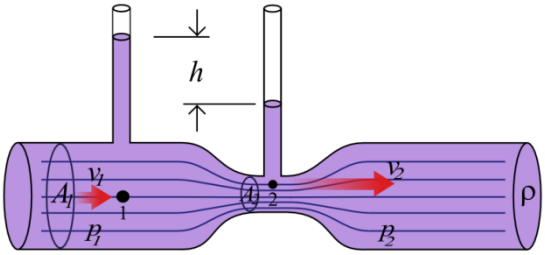
Question 1 – Hydrodynamics [35 marks]

1.1 State the following:

1.1.1 Torricelli's theorem, and (2)
1.1.2 Poiseuille's law. (2)

1.2 The figure below shows a Venturi meter, used to measure the flow speed in a pipe.



Show that the flow speed v_1 is related to the cross-sectional areas A_1 (of the wider section), A_2 (of the constricted section), and the difference in height h of the liquid levels in the two vertical tubes, according to the equation

$$v_1 = \sqrt{\frac{2gh}{(A_1/A_2)^2 - 1}}$$

(7)

1.3 An airplane has an effective wing surface area of 16 m^2 that is generating the lift force. In level flight the air speed over the top of the wings is 62.0 $m.s^{-1}$, while the air speed beneath the wings is 54.0 $m.s^{-1}$. What is the weight of the plane?

1.4 A paperweight, when weighed in air, has a weight of W = 6.9 N. When completely immersed in water, however, it has a weight of W = 4.3 N. Calculate the volume of the paperweight. (6)

1.5 Water at 20^{o}C flows through a pipe of radius 8.50 mm. The viscosity of water at this temperature is 1.005 centipoise. If the flow speed at the centre is 0.20 $m.s^{-1}$ and the flow is laminar, find the pressure drop due to viscosity along a 3.00 m section of the pipe. (5)

1.6 Derive an expression for the terminal speed v_t of a sphere falling in a viscous fluid in terms of the sphere's radius r and density ρ and the fluid viscosity η, assuming that the flow is laminar so that Stokes' Law is valid. (7)

Question 2 – Nuclear Physics [28 marks] **Start on a new page**

2.1 Differentiate between the following terms:

2.1.1 half-life and mean life-time of a radioactive material, and (4)
2.1.2 nuclear fission and nuclear fusion . (4)

2.2 Calculate the mass defect (in atomic mass units) **and** the binding energy *per* nucleon (in MeV) of the nuclide $^{15}_{6}C$ (atomic mass = 15.007306 u). (8)

2.3 The practical limit to ages that can be determined by radio carbon dating is about 41 000 yr. In a 41 000-yr-old sample, what percentage of the original Carbon-14 atoms remains? (6)

2.4 What is "X" in each of the following radioactive processes?
[Show **fully** how you arrived at your answers].

2.4.1 $^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + X$

2.4.2 $^{14}_{6}C \rightarrow {}^{14}_{7}N + X$

2.4.3 $^{231}_{90}Th* \rightarrow {}^{231}_{90}Th + X$

2.4.4 $^{239}_{93}Np \rightarrow {}^{239}_{94}Pu + X$

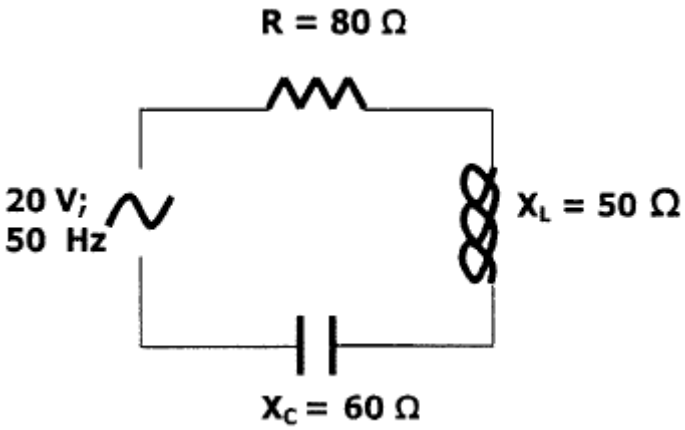
2.4.5 $^{238}_{92}U \rightarrow {}^{234}_{90}Th + X$

2.4.6 $^{46}_{24}Cr \rightarrow {}^{46}_{23}V + X$ (6)

Question 3 – AC Theory [28 marks] **Start on a new page**

3.1 Explain what is meant by the term *resonance* in an ac circuit (2)

3.2 For the circuit shown below, calculate

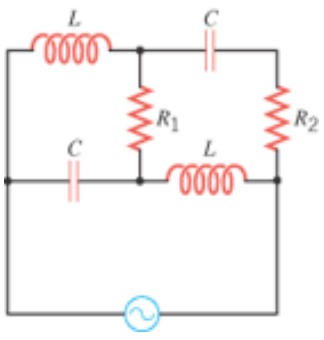


3.2.1 The current in the circuit.
3.2.2 The potential difference across each unit.
3.2.3 The power absorbed by the circuit. (9)

3.3 Fluorescent lights often use an inductor, called a “ballast”, to limit the current through the tubes. Why is it better to use an inductor than a resistor for this purpose? (2)

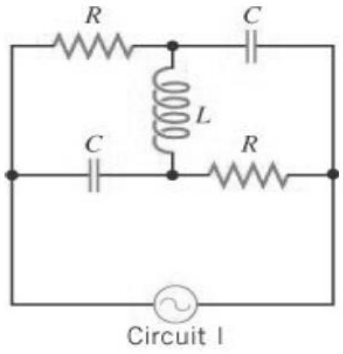
3.4 The resonant frequency of a series RCL circuit is 9.3 kHz. The inductance and capacitance of the circuit are each tripled. What is the new resonant frequency? (5)

3.5 In the circuit shown below, the generator delivers four times as much current at very low frequencies as it does at very high frequencies. Find the ratio R_2/R_1 of the resistances. (5)

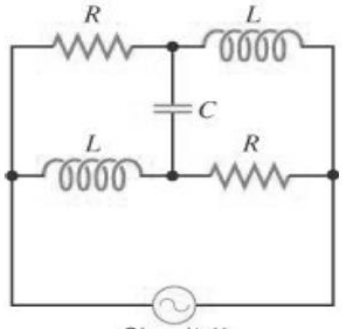


3.6

In the circuits shown, the *rms* voltage of the generator is the same. The values of resistance, capacitance and inductance are also the same. For which of the two circuits does the generator deliver more current when the frequency is very large?
Justify your answer. (5)



Circuit I



Circuit II

Question 4 - Thermodynamics [35 marks] **Start on a new page**

4.1 State the following laws:

4.1.1 The Zeroth of Law of Thermodynamics, and (2)
4.1.2 The Third Law of Thermodynamics. (2)

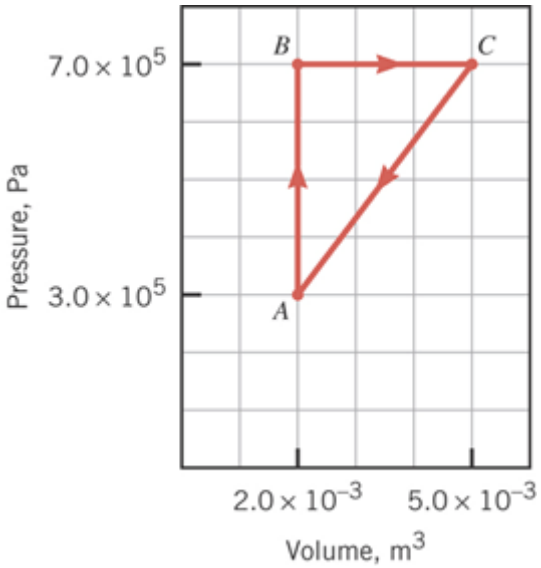
4.2 A monatomic ideal gas has an initial temperature of 405 K. This gas expands and does the same amount of work whether the expansion is adiabatic or isothermal. When the expansion is adiabatic, the final temperature of the gas is 245 K. What is the ratio of the final to the initial volume when the expansion is isothermal? (6)

4.3 Air at 20.0 ^{o}C in the cylinder of a diesel engine is compressed from an initial pressure of 1.00 atm and a volume of 800.0 cm^3 to a volume of 60.0 cm^3. Assume that air behaves as an ideal gas with $\gamma = 1.40$ and the compression is adiabatic. Calculate

4.3.1 The final pressure (in atmospheres), and (3)
4.3.2 The final temperature of the air (in ^{o}C). (3)

4.4 The pressure and volume of a gas are changed along the path *ABCA*. Using the data shown in the graph below, determine the work done (including the algebraic sign) in each segment of the path:

4.4.1 *A* to *B*, (3)
4.4.2 *B* to *C*, and (3)
4.4.3 *C* to *A*. (3)



4.5 Draw a fully labelled *PV* diagram (the Otto cycle) summarizing the operation of an internal combustion engine. (5)

4.6 An ice-making machine operates in a Carnot cycle. It takes heat from the water at 0.0°C and rejects heat to a room at 24.0°C. Suppose that 85.0 kg of water at 0.0°C are converted to ice at 0.0°C.

4.6.1 How much heat is rejected to the room? (3)
4.6.2 How much energy must be supplied to the device? (2)

Question 5 – Heat Transfer [14 marks] **Start on a new page**

5.1 Define or state the following terms

5.1.1 Convection (2)
5.1.2 Newton's Law of Cooling (2)

5.2 A large hot water tank has four legs in the form of cylindrical rods which are 2.0 cm in diameter and 15 cm long. The lower ends of the legs are in good thermal contact with the floor which is at 25^{o}C, and their upper ends can be taken to be at the temperature of the water in the tank. The tank and the legs are well lagged so that the only heat loss is through the legs. It is found that 20 W of power are needed to maintain the tank at a temperature of 58^{o}C. Calculate the thermal conductivity of the material which the legs of the tank are made of. (6)

5.3 A person is standing outdoors in the shade where the temperature is 28 °C. What is the radiant energy absorbed per second by his head when covered with hair? The surface area of the hair (assumed to be flat) is 160 cm^{2} and its emissivity is 0.85. (4)

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