UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2018/2019

TITLE OF PAPER:	INDUSTRIAL PHYSICS
COURSE NUMBER:	PHY496
TIME ALLOWED:	THREE HOURS
INSTRUCTIONS:	ANSWER QUESTION 1 AND CHOOSE ANY **THREE** OUT OF THE REMAINING QUESTIONS
	EACH QUESTION CARRIES 25 MARKS
	MARKS FOR EACH SECTION ARE IN THE RIGHT HAND MARGIN
	GIVE CLEAR EXPLANATIONS AND USE CLEAR DIAGRAMS IN YOUR SOLUTIONS. MARKS WILL BE LOST WHERE IT IS NOT CLEAR HOW THE EQUATIONS USED WERE OBTAINED

THIS PAPER HAS SEVEN PAGES INCLUDING THE COVER PAGE

THE LAST PAGE CONTAINS INFORMATION THAT MAY BE USEFUL IN SOME QUESTIONS

IF IN DOUBT, RAISE YOUR HAND AND ASK

DO NOT OPEN THE PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE CHIEF INVIGILATOR

QUESTION 1: *COMPULSORY*

(a) Why is the payback method of determining the viability of an investment useful?
(2 marks)

(b) Discuss any 5 flaws of using the payback method to make investment decisions.
(10 marks)

(c) You work for a research institute where you outsource some tests at cost of E500 000 per month. You attend a conference where you see a demonstration of a machine that can perform the same tests. The cost of the machine is E96 000 000 and the monthly consumables are E5 000 and the labour cost to operate it is 60 000 per month. The equipment requires calibration once every year at a cost of E10 000. The salvage value of the machine after 10 years is E500 000. The company does not have enough money and can only provide a deposit of E55 000 0000 from its invested funds in which it earns an income of 15% annually. The loan to cover the rest of the purchase is at an interest of 12% per annum over 10 years.

i. Calculate the amount to be financed and find the annual payment for the loan.
(3 marks)

ii. Find the lost income for the company over ten years for the amount used as a deposit, and convert it to an average annual figure. (This lost income is accounted as a cost.)
(3 marks)

iii. Find the payback period for the investment in the machine. **(5 marks)**

iv. What argument would you put forward to either or not purchase the machine.
(2 marks)

QUESTION 2

(a) Fully discuss the principle of operation of a photomultiplier tube and also make a typical schematic representation for its biasing circuit. **(8 marks)**

(b) Describe how the Czerny-Tuner configuration can be used both as a monochromator and spectrograph. **(8 marks)**

(c) A diffraction grating has 5 000 lines uniformly spaced over a width of 3.50 cm, and is used in the second order to resolve the iron spectral lines at 587.90, 587.80 and the 587.8002 nm.

i. What is the resolving power of this grating. **(3 marks)**

ii. Determine whether or not it is possible to resolve these lines or all the three of them are blurred into one line. **(6 marks)**

QUESTION 3

(a) Discuss the operation of a quadrupole mass spectrometer. **(12 marks)**

(b) Briefly list the pros and cons of a quadrupole mass spectrometer? **(8 marks)**

(c) A mass spectrometer has a resolution of 1 000. Find out whether or not it can it resolve species with m/q = 1060.2 and m/q = 1061.2. **(3 marks)**

(d) For the instrument mentioned in (c) determine the minimum separation of masses that it can resolve. **(2 marks)**

QUESTION 4

(a) In the study of vacuum processes, the ideal gas laws is usually used to describe the remaining gas particles. What is the limitation of the ideal gas law? **(3 marks)**

(b) What do you understand by a vacuum? **(1 mark)**

(c) Explain whether a perfect vacuum exist anywhere in the universe? **(2 marks)**

(d) Make a labeled schematic diagram showing how you can set-up a high to ultrahigh vacuum system. **(12 marks)**

(e) What is the number of particles in a vacuum chamber with an inside pressure of 7.50×10^{-8} Torr at 25.0°? **(2 marks)**

(f) Suppose a clean silicon wafer is placed in the chamber mentioned in part (e) at atmospheric pressure, how quickly will a monolayer of Oxygen form on a clean Silicon surface assuming a sticking coefficient of unity. **(5 marks)**

QUESTION 5

(a) Derive Benoulli's equation. **(10 marks)**

(b) Distinguish between dynamic and kinematic viscosity. **(4 marks)**

(c) Fresh water at 25.0° with dynamic viscosity $\eta = 8.90 \times 10^{-4}$ Pa·s flows at a rate $q_V = 0.470$ m^3/s through 500 m of 110 mm diameter PVC pipe with an absolute roughness of 0.003 mm. The density of water at this temperature is 997 kg/m^3.

i. Determine the head loss. **(8 marks)**

ii. What difference would it make in pressure if the pipe slopes down at 10.0° in the direction of flow. **(3 marks)**

DATA SHEET

General data

Air refractive index = 1.00
Avogadro's number $N_A = 6.022 \times 10^{23}$ mol^{-1}
Boltzmann's constant $k_B = 1.38 \times 10^{-23}$ J/K
Coulomb constant $k_e = 8.9875 \times 10^9$ N·m^2/C^2
Density of mercury = 1.36×10^4 kg/m^3
Gas constant $R = 8.314$ J/(mol.K)
Gravitational acceleration $g = 9.80$ m/s^2
Speed of light in vacuum $c = 2.997\,8 \times 10^8$ m/s
Speed of sound in air $v_s = 343$ m/s
Standard atmospheric pressure = 1.013×10^5 Pa

Some equations that may be useful

$$A = P\left(\frac{i}{1-(1+i)^{-n}}\right)$$

$$F = P(1+i)^n$$

$$P = A\left[\frac{(1+i)^n-1}{i(1+i)^n}\right]$$

$$h_f = f\frac{L}{D}\frac{v^2}{2g}$$

$$f = 0.110\left(\frac{\varepsilon}{D}+\frac{68.0}{Re}\right)^{0250}$$

$$n = 9.66 \times 10^{18} \times \frac{P}{T}$$

$$f(v) = 4\pi v^2\left(\frac{m}{2\pi k_B T}\right)e^{-mv^2/2k_BT}$$

$$\Gamma = n_V\left(\frac{k_BT}{2\pi m}\right) = \frac{Nv_{ave}}{4} = \frac{P}{(2\pi kT)^{1/2}}$$

$$N = \frac{P}{k_BT}$$

$$v_{ave} = \sqrt{\frac{8k_BT}{\pi m}}$$