UNIVERSITY OF ESWATINI

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

RE-SIT EXAMINATION 2018/2019

TITLE OF PAPER:	INTRODUCTORY PHYSICS I
COURSE NUMBER:	PHY101
TIME ALLOWED:	THREE HOURS
INSTRUCTIONS:	ANSWER ANY FOUR OUT OF FIVE 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 DATA THAT MAY BE USEFUL IN SOME QUESTIONS

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

QUESTION 1

(a) Given vectors $\vec{A} = 4.00\hat{\imath} + 2.00\hat{\jmath} + 3.00\hat{k}$ and $\vec{B} = 3.00\hat{\imath} + 4.00\hat{\jmath} - 2.00\hat{k}$, find the angle between the two vectors using the *dot product* $\vec{A} \cdot \vec{B}$. **(6 marks)**

(b) A body starts at the origin with a velocity of 4.00 m/s and accelerates to 14.0 m/s in 4.00 s, and then moves at constant velocity for 5.00 s, after which it accelerates to – 6.00 m/s in 5.00 s. Sketch

i. the velocity-time, **(4 marks)**

ii. the acceleration-time, and **(5 marks)**

iii. the distance-time graphs for this motion. **(6 marks)**

(c) A projectile is fired from an altitude of 30.0 m above ground with a velocity of 70.0 m/s at an angle $\theta = 38.0°$ with the horizontal. Find the highest point above ground reached by the projectile. **(4 marks)**

QUESTION 2

(a) The system shown in Figure 1 is in equilibrium. The coefficient of static friction between m_1 and the horizontal surface is 0.675. Find the tension in each cord and the masses m_1 and m_2. **(7 marks)**

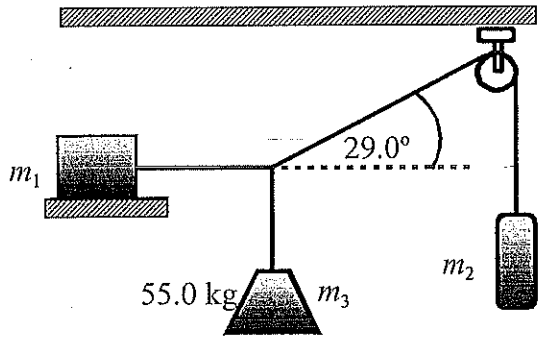

Figure 1. Mass system in equilibrium.

(b) The system shown in Figure 2 below is accelerating to the right.

i. Make resolved force diagrams for each mass and **(4 marks)**

ii. write down the associated equation resolved force equations **(4 marks)**

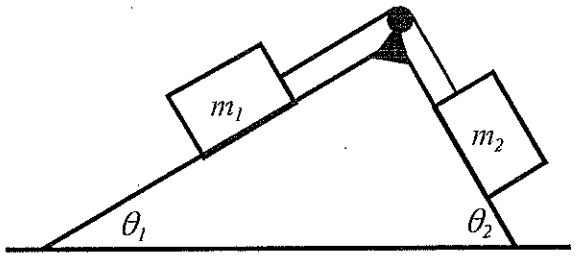

Figure 2. System accelerating to the right.

(c) A 70.0 kg person stands 0.500 m from the left edge of a uniform plank 2.00 m long of mass 30.0 kg suspended by three ropes providing tension T_1, T_2 and T_3, where the last two tensions are along the $-x$- and y-axis, respectively, as shown in Figure 3.

i. First find the tension T_1, and **(7 marks)**

ii. Then the tensions T_2 and T_3. **(3 marks)**

Figure 3. Person standing on a suspended plank.

QUESTION 3

(a) Two masses one of m and $4m$, both originally at rest are subjected to the same force $\vec{F}$ over the same distance $\vec{l}$ from point a to b in a region with no friction.

i. From your understanding of the relation between work and kinetic energy, explain which body will have the higher kinetic energy at point b, or would you expect them to have the same kinetic energy? **(4 marks)**

ii. Show which body will have the higher velocity if their velocities will be different? **(2 marks)**

(b) A vehicle of mass 1459 kg moving with a velocity of 48.28 m/s hits a big tree and the impact force collapses the car 0.3048 m in the front. Find the average force of impact on the car. **(4 marks)**

(c) A car of mass 1200 kg on a horizontal road makes an emergency stop such that all four wheels lock and it skids. The coefficient of friction between tires and road is $\mu = 0.800$.

i. Use the energy method to determine the stopping distance if the vehicle was originally moving at 80.0 km/h (22.2 m/s), and **(4 marks)**

ii. if it was moving at 120 km/h (33.3 m/s). **(4 marks)**

(d) At an intersection a car of mass $m_1 = 1250$ kg moving east at a velocity $v_1 = 33.3$ m/s collides with another truck of mass $m_2 = 2750$ kg moving north at a velocity of $v_2 = 22.2$ m/s. The vehicles stick together as one wreckage after the collision.

i. Determine the angle the wreckage makes with the west-east direction. **(5 marks)**

ii. Find the velocity of the wreckage just after collision. **(2 marks)**

QUESTION 4

(a) A rod of diameter $d = 3.00$ cm, length $l = 25.0$ cm and a Young's modulus of 2.00×10^{10} N/m^2. What force must be applied to stretch the rod by 3.75 mm? **(5 marks)**

(b) A Styrofoam slab of density 475 kg/m^3, an area of 4.50 m^2 and a thickness of 30.0 cm is to be used to carry a load across Luphohlo dam. Starting by stating Archimedes Principle, determine the maximum load that can be carried by this slab without sinking. **(7 marks)**

(c) A hypodermic needle is filled with a medicine that has the same density as water. The barrel of the syringe has a cross-sectional area $A = 2.5 \times 10^{-5}$ m^2, and the needle has a cross-sectional area $a = 1 \times 10^{-8}$ m^2. (See Figure 5.) A force of 2.00 N is used on the plunger to push the medicine out. The medicine is exposed to atmospheric pressure.

i. What is the pressure applied to the medicine in the syringe? **(2 marks)**

ii. Show by calculation that the square of the velocity of the medicine inside the needle is much greater than velocity of the medicine the barrel? **(4 marks)**

iii. With what velocity does the medicine escapes through the needle? **(7 marks)**

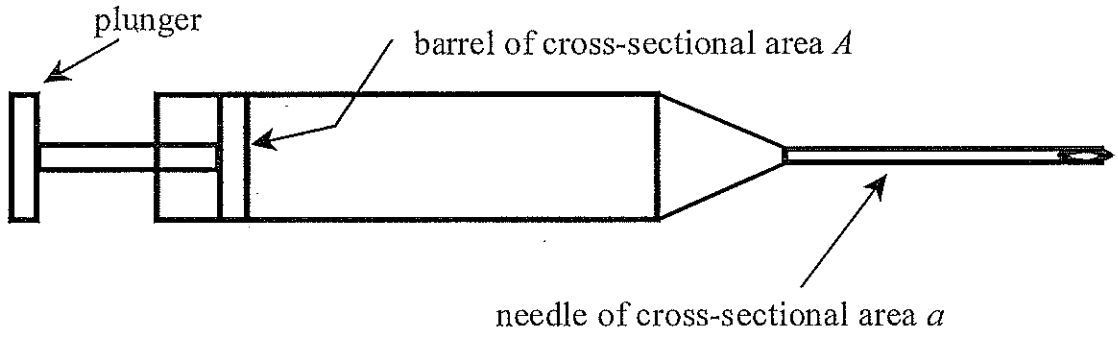

Figure 5. Hypodermic needle with medicine.

QUESTION 5

(a) An aluminum cup of radius 2.52 cm and a height of 5.00 cm is completely filled with glycerin at 22.0°C. Both the cup and the glycerin are heated to 28.0°C? The coefficient of thermal expansion of aluminium is $\alpha = 23.0 \times 10^{-6}/°C$ and volumetric thermal expansion of glycerin is given by $\beta = 5.10 \times 10^{-4}/°C$.

i. Find the final radius of and height of the aluminium cup. **(3 marks)**

ii. Through the calculation of the volume of the glycerin at 32.0°C determine how much of it spills over at the final temperature. **(3 marks)**

(b) Why does your skin feel cool after being rubbed with methylated spirit? **(2 marks)**

(c) Ice of mass 350 g at a temperature of 0.00°C is added to 750 g of water at 25.0°C in a perfectly insulating container.

i. Show by calculation that ice is left over when equilibrium is reached. **(4 marks)**

ii. Find the amount of ice that is left over. **(4 marks)**

(d) A broom handle made of wood and a copper rod of the same dimensions, are both left outside overnight on a very cold day. If they are both picked by a human hand which of the two will feel colder and why? **(3 marks)**

(e) An ideal gas is contained in a cylinder of some volume at gauge pressure of 995 kPa at a temperature of 27.0°C. A fire breaks out where the cylinder is kept and the temperature inside rises. The average temperature of a house fire is 593°C. The cylinder will burst if the pressures reaches 6895 kPa in the event the pressure relief valves fails to activate at 2585 kPa to release the gas before the pressure accumulates further. Determine whether the gas will be lost in either of these two ways (release by pressure release valve or bursting of cylinder). The coefficient of volumetric expansion for steel is $39.0 \times 10^{-6}/°C$. **(6 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
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
Refractive index of air $n_{air} = 1.000$
Standard atmospheric pressure = 1.013×10^5 Pa
Speed of light in vacuum $c = 2.997\ 8 \times 10^8$ m/s
Speed of sound in air $\upsilon_s = 343$ m/s
Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}$ W/(m^2·K^4)
Threshold of hearing $I_0 = 10^{-12}$ W/m^2
Universal gravitational constant $G = 6.67 \times 10^{-11}$ N. m^2/kg^2
1 calorie = 1 c = 4.186 J
1 food calorie = 1 Calorie = 1C = 10^3 calories = 4.186×10^3 J

Water data

$c(water) = 4186$ J/(kg·K) $c(ice) = 2090$ J/(kg·K) $c(steam) = 2079$ J/(kg·K)
$L_f(ice) = 3.33 \times 10^5$ J/kg $L_v(water) = 2.260 \times 10^6$ J/kg
ρ (water) = 1000 kg/m^3 refractive index $n_w = 1.333$

Electricity and nuclear data

Alpha particle mass = $6.644\ 657 \times 10^{-27}$ kg
Charge of an electron = -1.6×10^{-19} C
Charge of a proton = $+1.6 \times 10^{-19}$ C
Coulomb's constant $k_e = 8.987\ 5 \times 10^9$ Nm^2/C^2
Deuteron mass = $3.343\ 583 \times 10^{-27}$ kg
Electron mass, $m_e = 9.109 \times 10^{-31}$ kg
Neutron mass $m_n = 1.675 \times 10^{-27}$ kg
Proton mass, $m_p = 1.673 \times 10^{-27}$ kg
1 atomic mass unit = 1 amu = 1 u = 1.66×10^{-27} kg
$\epsilon_0 = 8.85 \times 10^{-12}$ C^2(N·m^2)
1 Ci = 3.7×10^{10} decays/s
1Bq = 1 decay/s