UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

SUPPLIMENTARY EXAMINATION 2015/2016

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 two vectors $\vec{A} = 3\hat{\imath} + 2\hat{\jmath} - 4\hat{k}$ and $\vec{B} = \hat{2\imath} - 3\hat{\jmath} + 5\hat{k}$, find

i. the magnitude of the two vectors, **(2 marks)**
ii. the dot product of the two vectors, and **(2 marks)**
iii. the angle between the two vectors. **(2 marks)**

(b) A body starts at the origin with a velocity of 4 m/s and accelerates to 16 m/s in 4 s, and then moves at constant velocity for 5 s after which it accelerates to - 4m/s in 5 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 body is projected vertically upward with a velocity of 30 m/s. Find the velocity of the body at a height of 20 m and comment about your solution. **(4 marks)**

QUESTION 2

(a) The two blocks in Figure 1 are connected by strings of negligible mass that pass over a frictionless pulley. The coefficient of kinetic friction between the masses m_1 and m_2 is μ. The system has an acceleration a to the right.

i. Make fully labeled force diagrams for each mass from which useful equations of motion can be obtained, that can enable you to obtain the acceleration of the system if all quantities are given. **(6 marks)**

ii. Write down the equations of motion for each mass that can enable you to find the acceleration of the system, if all quantities are given. **(6 marks)**

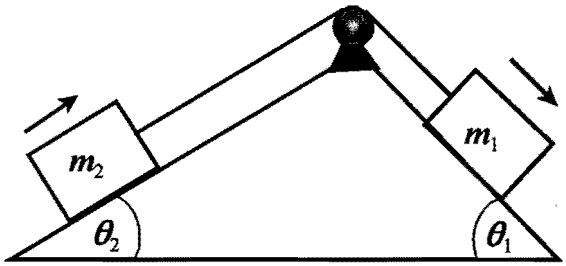

Figure 1.

(b) A uniform beam of length 12 m with a weight of 2400 N is supported as shown in Figure 2. The person of mass 75 kg is sitting 3.5 m from the wall. The box of supplies is placed on the beam 7 m from the wall.

i. Find the tension in the cable. **(6 marks)**

ii. Find the x- and y-components of the reaction force by the wall. **(3 marks)**

iii. Find the angle ϕ the reaction force makes with the wall. **(2 marks)**

iv. Illustrate the force due to the wall and the angle ϕ. **(2 marks)**

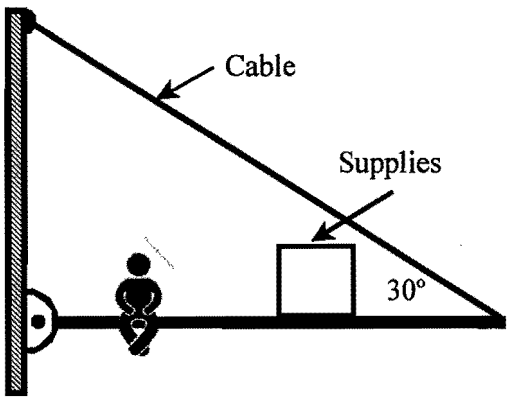

Figure 2.

QUESTION 3

(a) A body is projected vertically upward with a velocity of 20.0 m/s. Use energy methods to determine its speed at a height of 15.0 m, and comment on the result. **(5 marks)**

(b) A mass $m = 5.00$ kg is attached to a spring of spring constant $k = 120$ N/m that is placed against a stop. The mass is pressed against the spring such that it is compressed a distance of 10.0 cm on a frictionless surface. Find the speed of the mass when the spring extends back to its original length. **(5 marks)**

(c) A bullet of mass $m = 4.20$ g moving with an initial supersonic velocity $v_0 = 965$ m/s strikes a stationary block of mass $M = 4.00$ kg resting on a frictionless surface. The block acquires a velocity $V' = 5.00$ m/s in the original direction of the bullet.

i. What is the final velocity of the bullet v_f after the collision? **(4 marks)**

ii. Describe the motion of the bullet after the collision, and state which of the cases in Figure 3 below resembles the motion of the system after impact. **(2 marks)**

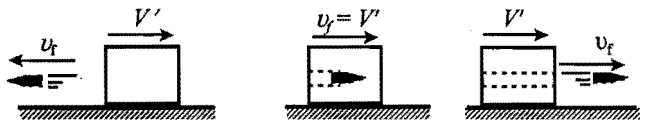

Figure 3. (a) (b) (c)

(d) A flywheel of moment of inertia $I = 155$ kg m^2 is accelerated from 850 rpm to 6500 rpm in 5.00 s.

i. Find the angular acceleration and the torque on the wheel? **(5 marks)**

ii. What torque was used to accelerate the wheel? **(1 mark)**

iii. What angle in radians does it turn through in the first 5.00 s? **(3 marks)**

QUESTION 4

(a) A piece of wire of length 5 m and diameter 0.450 mm suspends a mass of 20 kg in air. The wire extends by 0.254 mm under this load.

i. Calculate the stress and strain on the wire. **(5 marks)**

ii. Find the Young's modulus for the wire. **(2 marks)**

(b) A PHY101 student of mass $m = 55.0$ kg who cannot swim but wants to enjoy time in the swimming pool of fresh water. She finds a slab of wood of thickness $t = 10.0$ cm, and a density of 800 kg/m^3 (See Figure 4). What should be the minimum area of the slab of wood to support the student? **(6 marks)**

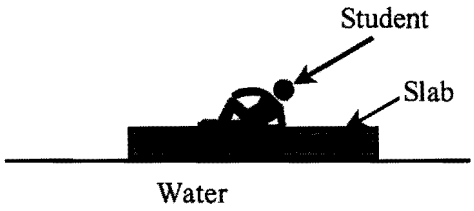

Figure 4

(c) The safe depth underwater a human can be is said to be about 30.0 m. Find the gauge and absolute pressures at this depth. **(4 marks)**

(d) A sealed tank contains water for a fire hydrant to a level of 20.0 m. Above the water level there is air at a pressure of 6.00 atmospheres. The hose is connected at the bottom of the tank used to extinguish fires. Suddenly the hose breaks off from the tank. Use Bernoulli's equation to determine the velocity with which the water comes out at the bottom of the tank. State all assumptions made. **(8 marks)**

QUESTION 5

(a) On a day when the temperature is 98°F. What is the temperature in °C? **(2 marks)**

(b) A concrete slab of length 5.00 m is at a temperature of −5.00°C in the early morning. In the midafternoon the temperature of the slab rises to 42.0°C. The slab is free to expand in all directions. Determine the length of the concrete slab at midafternoon if its thermal coefficient of expansion is $14.5 \times 10^{-6}(°C)^{-1}$. **(3 marks)**

(c) List the three mechanisms by which heat is transferred from one region to another and the medium required for each case. **(3 marks)**

(d) A wood stick and a steel rod are left outside in a cold night. In the morning, a student picks up the rod and the stick. Which of the two will feel colder and why? **(4 marks)**

(e) A 200 g insulated copper calorimeter of heat capacity 385 J/kg·K contains 1200 g of water at a temperature of 18.0°C. How much steam at 110°C has to be condensed into the water if the final temperature of the system is to reach 40.0°C? **(9 marks)**

(f) A tank contains an ideal gas at a pressure of 2 atmospheres. It is heated at constant volume to a temperature of 700°Cg. Find the final pressure in Pascal. **(4 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