UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2016/2017

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

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(a) If the vectors are $\vec{A} = 2\hat{\imath} - 4\hat{\jmath} + 5\hat{k}$ and $\vec{B} = \hat{\imath} + 2\hat{\jmath} - 3\hat{k}$ find the angle between the two vectors using the cross product. **(7 marks)**

(b) The motion of a body is described by the velocity-time graph shown in Figure 1. Draw

i. the acceleration-time and **(4 marks)**

ii. displacement time graphs for this motion. **(5 marks)**

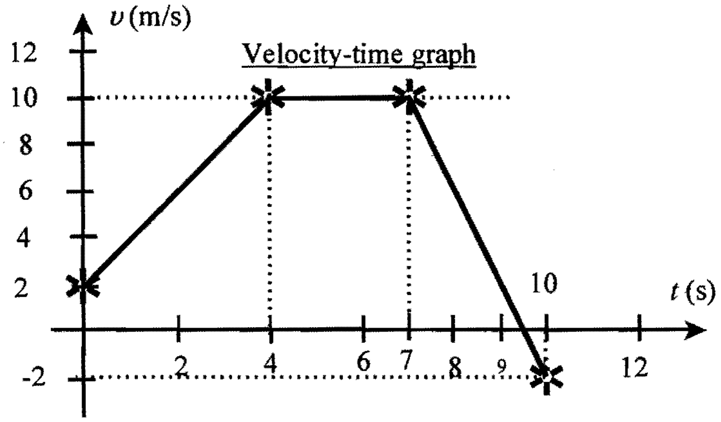

Figure 1.

(c) A basketball player standing on the floor 10 m from the basket hoop shoots a basketball from a height of 2 m, (see Figure 2). The initial velocity of the ball is v_0 = 10.7 m/s and leaves the hands of the player at an angle $\theta = 40°$ with the horizontal. The ball hits the basket after reaching the highest point.

(i) Find the time the basketball spends in flight to the basket hoop? **(3 marks)**

(ii) What is the height h of the hoop above ground? **(4 marks)**

(iii) Determine the x and y-component of the velocity of the ball when it enters the basket hoop. **(2 marks)**

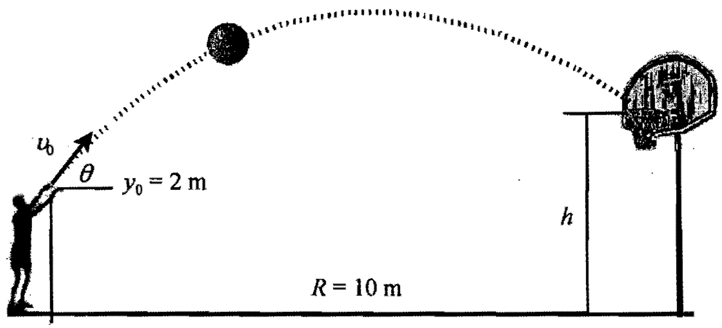

Figure 2.

i.

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QUESTION 2

(a) The system shown in Figure 3 is originally in equilibrium. The beam is uniform 10 m long, weights 800 N and mass of supplies $m_s = 300$ kg is placed on it 2.00 m from the wall. The cable is attached 6.00 m from the wall and makes an angle of 50.0° with the beam and can support a maximum load of 4894 N. A horse pipe is used to fill the tank with water. When the mass of the water tank and the water m_{wt} reaches 86.5 kg the cable snaps.

i. Determine the position x where the water tank was placed just before the cable snapped. **(6 marks)**

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

iii. Find the angle the force due to the wall makes with the horizontal. **(2 marks)**

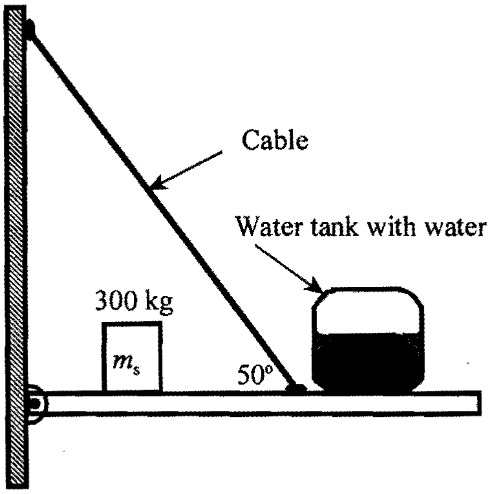

Figure 3.

(b) The system shown in Figure 4 is in equilibrium. The coefficient of friction between the masses m_2 and m_3 and the inclined surface is μ. Find an expression for the mass m_1

i. if the system is about to move to the right, and **(7 marks)**

ii. when the the system is about to move to the left. **(7 marks)**

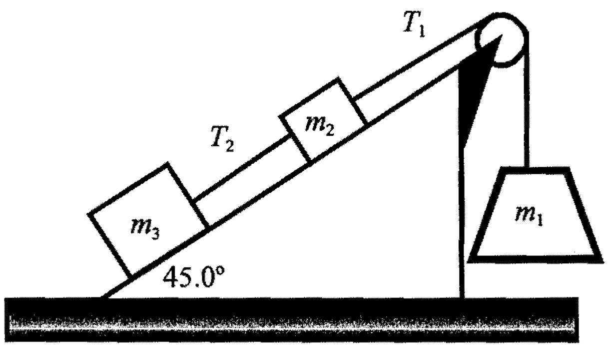

Figure 4.

QUESTION 3

4

(a) A linear spring of spring constant $k = 2.70 \times 10^2$ N/m and natural length $l_0 = 15.0$ cm is held against a stop on the left end. It is then compressed a distance $A = 10.0$ cm with a mass $m = 4.00$ kg, and let go. Find the velocity of the mass when the spring stretches to $x = 5.00$ cm. The problem is illustrated by the diagrams in Figure 5. **(6 marks)**

(b) A head-on collision occurs between a truck of mass $M = 4500$ kg moving towards the right at $v_t = 33.3$ m/s and a car of mass $m = 1200$ kg moving towards the left with a velocity $v_c = 33.3$ m/s. Both vehicle masses include the masses of the drivers, each of mass 70 kg. The collision time is 0.105 s. After the collision, the two vehicles stick together making one wreckage that moves in the original direction of the truck.

i. Find the velocity of the wreckage just after impact. **(5 marks)**
ii. Determine the force of collision on each vehicle. **(4 marks)**
iii. Find the force the seatbelt exert on each driver. **(4 marks)**
iv. Comment on the force of impact on the vehicles and the force of impact experienced by each of the drivers. **(2 marks)**

(c) A rigid rod of moment of inertia $I = 1.50$ kg·m^2 about the x-axis has three masses arranged as shown in Figure 6. The system rotates about the x-axis with angular speed of 2.00 rad/s. Calculate

i. the moment of inertia of and **(3 marks)**
ii. the kinetic energy of the system? **(1 mark)**

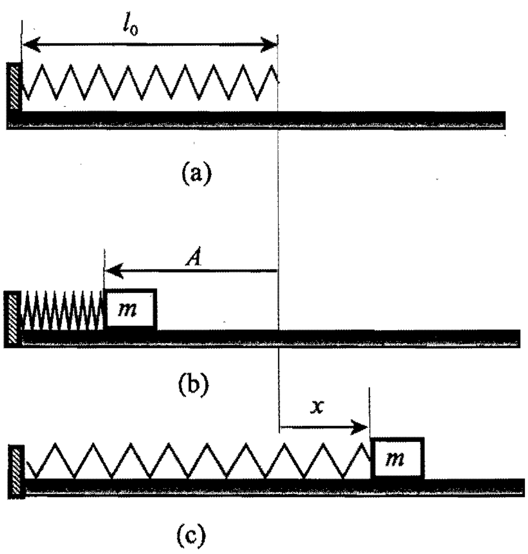

Figure 5.

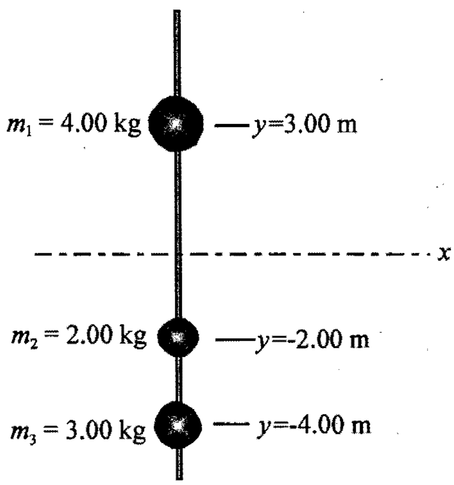

Figure 6.

QUESTION 4

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(a) Sketch and explain a stress strain graph for materials such as vulcanised rubber, and give an example where such material are used. **(7 marks)**

(b) Give examples of applications where you would be more concerned about the applied stress than force and explain why. **(2 marks)**

(c) A cubic block of cherry wood has density of 630 kg/m^3 and has a dimension of 10.0 cm per side, and float on fresh water.

i. Determine the depth of the bottom surface of the cube below the water level, and **(5 marks)**

ii. the maximum mass that it can supported without sinking. **(5 marks)**

(d) Water is flowing in a fire hose with a velocity of 1.0 m/s and a pressure of 200 000 Pa. At the nozzle the pressure decreases to atmospheric pressure, there is no change in height. Use the Bernoulli equation to calculate the velocity of the water exiting the nozzle. **(6 marks)**

QUESTION 5

(a) If a steel railroad rail of length 10.0 m and coefficient of linear expansion $11.0 \times 10^{-6} {}^{\circ}C^{-1}$ is laid on a day when the temperature is 10.0°C. A PHY101 student on a field trip decides to measure the length of the rail using a precision instrument and finds it to be 10.00495 m. Determine the temperature of the rail at the time of measurement. **(4 marks)**

(b) An 100-g aluminum cup of heat capacity 385 J/kg·K contains 200 g of water at 18.0°C. Dry steam of mass 23.2 g at 100°C is passed into water to reach an equilibrium temperature. Find the final temperature of the system assuming negligible heat losses to the surroundings. **(10 marks)**

(c) Vehicles use tyres which when inflated with air at room temperature raise the body of the vehicle an appreciable distance from the ground. This means that the air in the tyres exert a force to lift the vehicle. To illustrate the force magnitude of the force exerted by air consider a cube 10.0 cm on each edge containing air with an equivalent molar mass of 28.9 g/mol at atmospheric pressure and temperature of 25.0°C.

i. Find the mass and the weight of the gas. **(4 marks)**
ii. Determine the force exerted by the gas on each face of the cube. **(2 marks)**
iii. Explain how such a small amount of gas can exert such a great force. **(5 marks)**

DATA SHEET

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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 = $1.36 \times 10^4\ kg/m^3$
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 $\sigma = 5.67 \times 10^{-8}\ W/(m^2 \cdot K^4)$
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
$\epsilon_0 = 8.85 \times 10^{-12}\ C^2(N \cdot m^2)$
1 Ci = 3.7×10^{10} decays/s
1Bq = 1 decay/s