UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

RESIT EXAMINATION 2019/2020

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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) For the two vectors $\vec{A} = 3.00\hat{\imath} - 2.00\hat{\jmath} + 4.00\hat{k}$ and $\vec{B} = 2.00\hat{\imath} + 3.00\hat{\jmath} + 5.00\hat{k}$, find

(i) the magnitude of each vector, **(2 marks)**

(ii) the dot product of the two vectors, and **(3 marks)**

(iii) the angle between the two vectors. **(2 marks)**

(b) A body with an initial velocity of 4 m/s is accelerated at 2 m/s^2 for 4 s. It then moves at constant velocity for 3 s after which it is accelerated at -4 m/s^2 for 4 s. Sketch

(i) the acceleration-time graph, **(4 marks)**

(ii) the velocity-time graph, and **(5 marks)**

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

(c) A bullet is shot vertically upward with a velocity of 800 m/s. How high does it rise? **(3 marks)**

QUESTION 2

10

(a) The systems shown in Figure 1 is in equilibrium. Find the tensions in each cord, T_1, T_2 and T_3, and the mass m_2. **(8 marks)**

(b) The system shown in Figure 2 is about to move to the right, i.e. m_1 is about to move down the inclined plane while m_2 is about to move up.

(i) Make force diagrams for the two masses. **(4 marks)**

(ii) Write down the equations of motion for each mass. **(4 marks)**

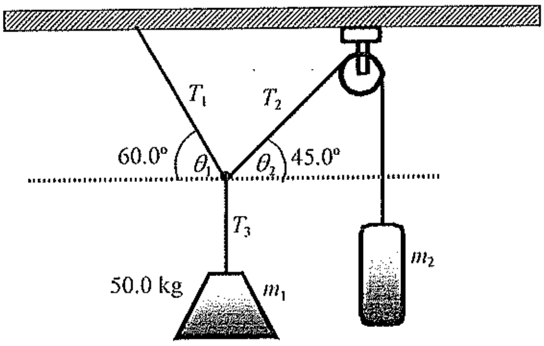

Figure 1.

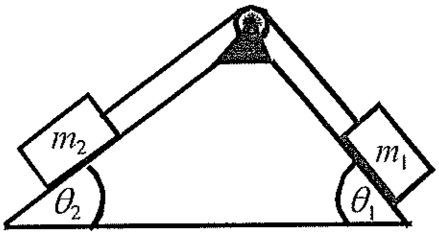

Figure 2.

(c) The system shown in Figure 3 is in equilibrium. The beam is uniform, 10.0 m long, and weighs 2000 N. The masses m_1 = 200 kg and m_2 = 300 kg are positioned at distances of 2.00 m and 6.00 m from the wall, respectively.

(i) Determine the tension in the cord. **(6 marks)**

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

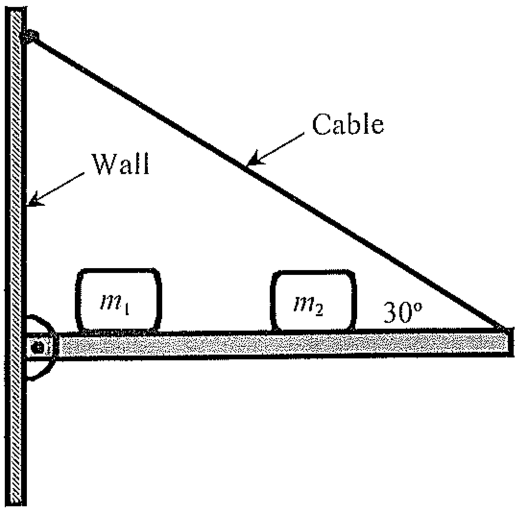

Figure 3.

QUESTION 3

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(a) List three ways where energy is transformed from one for to another in everyday life. **(3 marks)**

(b) A vehicle of mass $m = 1143$ kg is moving at a velocity of 27.78 m/s. When the brakes are fully applied it stops within a distance of 56.0 m. The coefficient of kinetic friction between the car tyres and the road surface is 0.700

i. Determine the original kinetic energy of the vehicle. **(1 mark)**
ii. What was the stopping force on the car? **(3 marks)**

(c) Why is momentum useful to solve collision problems as compared to kinetic energy? **(3 marks)**

(d) A bullet of mass $m = 42.0$ g moving with an initial supersonic velocity $v_0 = 965$ m/s strikes a stationary block of mass $M = 1.45$ kg resting on a frictionless surface. The block acquires a velocity $V' = 1.25$ m/s, in the original direction of motion of the bullet. Find the velocity of the bullet v_f just after the collision, and based on your result explain what happens during the collision and compare the final motions of the two objects. **(5 marks)**

(e) A head-on collision occurs between a truck of mass $M = 4\,500$ kg moving towards the right at $v_t = 25.0$ m/s and a car of mass $m = 1245$ kg moving towards the left with a velocity $v_c = 25.0$ m/s. Both vehicle masses include the masses of the drivers, each of mass 65.0 kg. The collision time is 0.0260 s. After the collision, the two vehicles stick together forming one-wreckage that moves in the original direction of the truck.

i. Find the velocity of the wreckage just after impact. **(4 marks)**
ii. Find the force of impact on each driver. **(2 marks)**
iii. Comment fully on the answers you obtained in ii. Also relate your answer to the effect on occupants of smaller vehicles and as compared to those in bigger ones. **(4 marks)**

QUESTION 4

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(a) A certain person has bones having a Young's modulus $Y = 1.48 \times 10^{10}$ N/m^2, and maximum strength of 1.5×10^8 N/m^2.

(i) What is the maximum force that can be exerted on the femur bone in the leg if it has a minimum effective diameter of 2.50 cm? **(3 marks)**

(ii) If the femur has length $l_0 = 24.5$ cm and is subjected to a force of 62 500 by how much does the bone shorten under this force? (Assume the force is acting within the proportional region) **(4 marks)**

(b) A solid platform of area $A = 4.00$ m^2 and density $\rho_p = 650$ kg/m^3 is to be used to support a load of mass m_l = 850 kg on fresh water. Determine the thickness t of the platform to just support the load above the water. First state the principle used to solve this problem. **(8 marks)**

(c) An open tank contains water to a height of 10.0 m. A small hole develops at the bottom of the tank. Use Bernoulli's equation to determine the velocity with which the water comes out of the hole. State all assumptions made. **(8 marks)**

QUESTION 5

13

(a) On a day when the temperature is $98.0°\text{F}$, what is it in degrees Celsius and in Kelvin?
(2 marks)

(b) A steel bar at temperature T_0 is found to be 3.00 m long. It is left in the sun on a hot day and its temperature rises to $51.5°\text{C}$, and its length is found to be 30.008964 m. Find the temperature T_0. The coefficient of linear expansion for steel is $= 7.20 \times 10^{-6} °\text{C}^{-1}$. **(4 marks)**

(c) Why is it that on a cold day, a tile floor in a bathroom may feel uncomfortably cold to your bare feet, while a carpet floor in an adjoining room at the same temperature may feel comfortable?
(3 marks)

(d) An ice bath is made by adding 285 g of ice at -10.0°C to 795 g of water at 20.0°C in an insulated brass calorimeter of mass 200 g and heat capacity 385 J/(kg·K).

i. Show that the heat energy from the water is not enough to melt all the ice, and therefore an ice bath is formed. **(7 marks)**

ii. How much ice remains when the system reaches equilibrium? **(4 marks)**

(e) A tank contains a poisonous gas at pressure of 1.95 atmospheric pressure and a temperature of $18.0°\text{C}$ in a laboratory. The laboratory catches fire and the temperature for the gas rises to $750°\text{C}$. The container will explode if the pressure reaches 6.18×10^5 Pa. Determine whether the cylinder will burst or not. **(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

<u>Water data</u>

$c(water) = 4186$ 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 $n_w = 1.333$	

<u>Electricity and nuclear data</u>

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