UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

RESIT 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

(a) Given vectors $\vec{A} = 3\hat{\imath} + 2\hat{\jmath} - 5\hat{k}$ and $\vec{B} = 2\hat{\imath} - 2\hat{\jmath} + 4\hat{k}$ find the cross product of the two vectors. **(4 marks)**

(b) A body with an initial velocity of 4 m/s is accelerated at 2 m/s^2 for 3 s. It then moves at constant velocity for 4 s, after which it is accelerated at -2 m/s^2 for 5 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 body is projected vertically upward with a velocity $v_0 = 34.5$ m/s.

i. What is its velocity at $t = 4.25$ s? Also specify the direction of motion at this time. **(3 marks)**

ii. What is its velocity at a height of 15.0 m? Explain your solution. **(3 marks)**

QUESTION 2

(a) The system shown in Figure 1 is in equilibrium. The coefficient of static friction μ_s between m_2 and the surface is 0.400.

i. Make a force diagram for the system and find the tension in each cord. **(7 marks)**

ii. Find the masses m_1 and m_2. **(2 marks)**

(b) In Figure 2, m_1 is 5.00 kg and m_2 is 1.90 kg. A force F is applied as shown such that m_1 moves up the inclined plane with an acceleration of 2.00 m/s. The mass of the string and the friction in the pulley are negligible. The coefficient of kinetic friction μ_k between m_1 and the horizontal surface is 0.520. What is the magnitude of the applied force F? Start by making force diagrams for each mass to obtain the required equations. **(5 marks)**

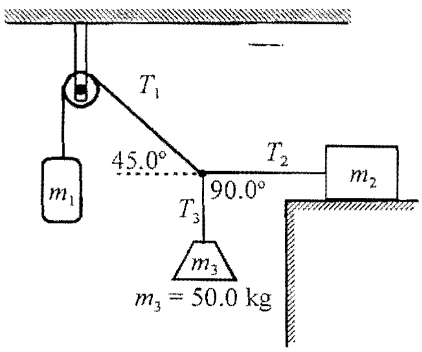

Figure 1.

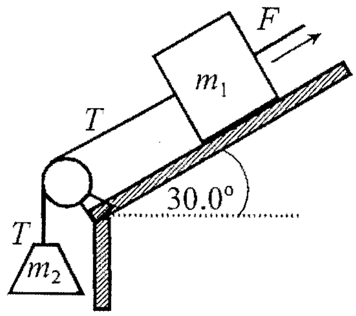

Figure 2.

(c) The system shown in Figure 3 is in equilibrium. The beam is uniform, 10.0 m long, and weighs 2000 N. The bags of cement are 2.50 m from the wall and have a mass of 300 kg.

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)**

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

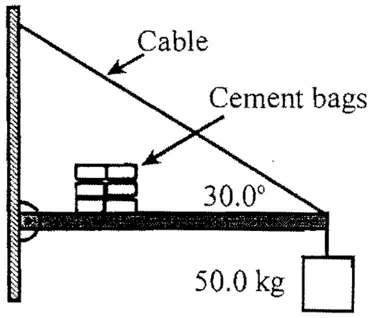

Figure 3.

QUESTION 3

(a) A body is projected upward with a velocity of 34,5 m/s. Use energy methods to determine

i. its maximum height h, and **(3 marks)**

ii. its velocity at a height $h' = 15.0$ m. **(3 marks)**

(b) A linear spring of natural length l_0 has a spring constant $k = 1250$ N/m is held against a stop. It is compressed a distance of 5.75 cm by a mass $m = 2.50$ kg.

i. What is the potential energy of the spring system? **(1 mark)**

ii. If the system is let go, what is the velocity of the mass m when the spring returns to its original length? **(2 marks)**

(c) A construction worker of mass 80.5 kg falls over a height of 20.0 m. The collision with the ground takes 0.0500 s.

i. Define force in terms of momentum. **(2 marks)**

ii. Determine the force of impact with the ground. **(4 marks)**

iii. Compare the force of impact to the weight of a 50.0 kg bag of cement, and use your own judgment to conclude as to whether the worker is likely to be injured in the collision with the ground. **(3 marks)**

(d) A machine has a mass of 75.2 kg located at a radius of 5.25 m from the centre and rotating with an angular velocity of 33.3 rpm.

i. What is the centripetal force on the mass? **(3 marks)**

ii. What is the moment of inertia of the mass about the axis of rotation? **(1 mark)**

iii. If the system was originally rotating at 15.0 rpm and it took 5.00 s for it to be accelerated to an angular velocity of 33.3 rpm, what was the angular acceleration of the system? **(2 marks)**

iv. If the entire system has a moment of inertial of 4500 $m^2 \cdot kg$ what is the toque required to accelerate it from 15.0 rpm to 33.3 rpm in 5.00 s? **(1 mark)**

QUESTION 4

(a) Sketch a fully labeled stress strain graph for a ductile metal. **(6 marks)**

(b) A human muscle of length $l_0 = 15.0$ cm with a cross-sectional area $A = 1.57 \times 10^{-4}$ m^2 is under a tension of 125 N. The muscle stretches by $\Delta l = 0.450$ mm under this load.

i. What is the stress on the muscle? **(1 mark)**

ii. What is the strain on the muscle? **(1 mark)**

iii. Find the Young's Y modulus for this muscle. **(1 mark)**

(c) A PHY101 student of mass $m = 55.0$ kg who cannot swim wants to enjoy time in the swimming pool. He finds a slab of wood of thickness $t = 10.0$ cm, and a density of 500 kg/m^3. Find the minimum area of the slab of wood to support the student? **(8 marks)**

(d) A sealed tank contains water for a fire hydrant to a level of 15.0 m. Above the water level there, is pressurised air at a pressure of 115080 Pa. 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)**

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QUESTION 5

(a) What is the temperature in degrees Celsius (°C) on a day when it is 98.5°F. **(2 marks)**

(b) A bridge is made of two adjacent steel segments (arranged end-to-end) each with a length of 259 m when the temperature is 25.0°C. The temperature of the steel can reach 50.0°C in summer. The coefficient of linear expansion for steel is $11.0 \times 10^{-6}{}^{\circ}C^{-1}$. Determine the required space that must be left between the two segments if the bridge is constructed when the temperature is 25.0°C to prevent the bridge from buckling when it reaches the maximum temperature. **(4 marks)**

(c) A 0.420 kg iron ball that is initially at 652°C is dropped into a bucket containing 19.0 kg of water at 22.0°C. What is the final temperature reached? Neglect any energy transfer to or from the surroundings. **(9 marks)**

(d) Discuss how the construction of a thermo flask reduce heat transfer between its contents and surroundings. **(6 marks)**

(e) An auditorium has dimensions 10.0 m × 20.0 m × 30.0 m. How many molecules of air fill the auditorium at 20.0°C, assuming that air is treated like an ideal gas. **(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 = $1.36 \times 10^4\ kg/m^3$
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