UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

MAIN 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 $\vec{A} = 2\hat{\imath} - 4\hat{\jmath} + 5\hat{k}$ 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) A rock is dropped from restvertically downward at the same instant that a ball is projected horizontally (parallel to the ground) at the same height.

i. Which object will arrive at the ground first neglecting air resistance? **(2 marks)**

ii. Which object will have a higher speed when it reaches the ground level? **(2 marks)**

(c) A car with faulty brakes is parked up an incline at 33.4° with the horizontal. The brakes fail while the driver is not in the vehicle and it moves such that it reaches the edge of a cliff down slope with a velocity of 40 m/s and goes over the clif. The cliff is 55.6 m high.

i. Find the x- and y-components of the velocity of the car just before it hits the bottom of the cliff. **(6 marks)**

ii. Write the velocity with which the car hits the bottom of the cliff in vector form, and calculate its magnitude. **(2 marks)**

iii. How much time does the car spend in flight before hitting the ground at the bottom of the cliff? **(2 marks)**

iv. What is the range of the car from the edge of the cliff? **(2 marks)**

v. Find the angle the velocity of the car makes with the ground, and provide a sketch illustrate this angle? **(2 marks)**

QUESTION 2

(a) A human leg is attached to a traction system as shown in Figure 1. The mass m is 10.0 kg. The force applied by the traction is opposite the direction of the reaction force F_{AB} by the leg which makes and angle θ with the horizontal.

i. Determine the angle θ. **(8 marks)**

ii. Determine the magnitude of F_{AB}. **(2 marks)**

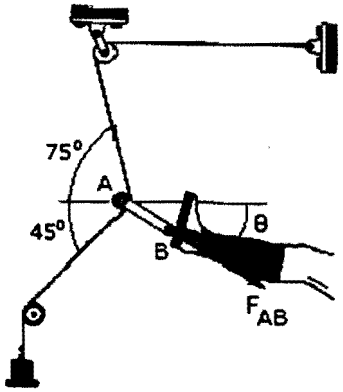

Figure 1.

(b) Blocks of mass m_1, m_2 and m_3 are attached by cords of negligible mass as shown in Figure 2. Both m_1 and m_2 have masses of 2.54 kg each, and the coefficient of kinetic friction between each block and surface is 0.500. The mass m_1 descends with an acceleration of 2.50 m/s^2. Find the mass m_1.

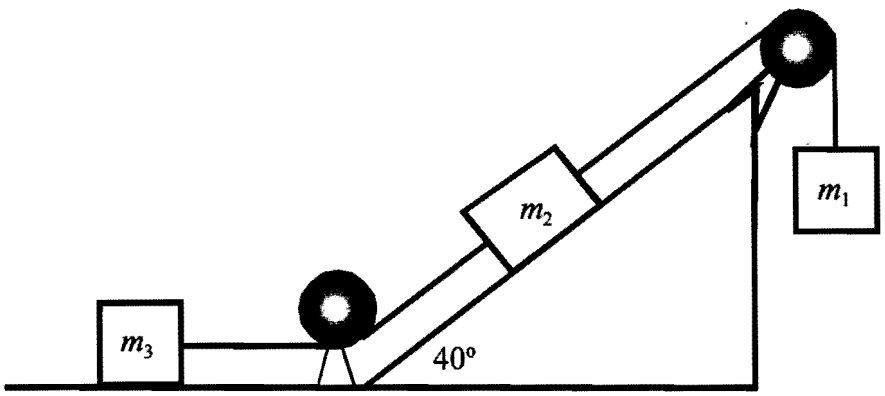

Figure 2.

i. Draw a force diagrams for the masses from which useful equations of motion can be obtained. **(5 marks)**

ii. Write down the equations of motion using the information in i. **(4 marks)**

iii. Find the mass m_1. **(6 marks)**

QUESTION 3

(a) Give an example to demonstrate that kinetic energy depends on the reference frame chosen. **(3 marks)**

(b) A certain uniform spring of spring constant k is cut in half. Each of the shorter springs will have spring constant k'. What is the relationship between k and k', **(4 marks)**

(c) A spring is fixed on an incline of angle θ with the horizontal supported by a stop at its lower end so that it cannot move. A mass of m with zero initial velocity is allowed to slide down the incline a distance d before it hits the spring (see Figure 3). The spring is compressed a maximum distance x after the impact. Find the distance d in terms of g, k, m, θ and x. **(6 marks)**

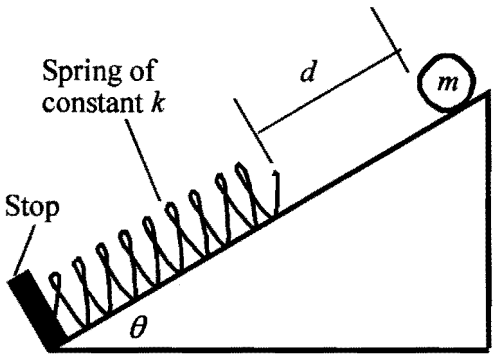

Figure 3.

(d) The driver of a small truck ($M = 1\,577$ kg) hits a stationary car ($m = 950$ kg) at a red traffic light from behind on a level ground. During impact both drivers have their brakes on all the way. The two cars stick together after the collision and travel a distance of 8.2 m before coming to rest. The coefficient of friction between the tyres of the vehicles and the rod surface is 0.72.

i. How much energy is lost in friction? **(3 marks)**

ii. What was the original velocity of the wreckage just after collision? **(3 marks)**

iii. How fast was the SUV travelling before the collision? **(3 marks)**

(e) The moment of inertia of the rotor of a centrifuge in a chemistry laboratory is $I = 3.40 \times 10^{-2}$ kg·m^2, and rotates at an angular velocity of 3 600 rpm. When switched off it rotates 50.0 times before coming to rest. Find the constant angular acceleration of the centrifuge, assuming that it is constant. **(3 marks)**

QUESTION 4

(a) Sketch a stress strain graph for a ductile metal and label all its parts. **(9 marks)**

(b) A certain person has a leg bone of Young's modulus 1.50×10^{10} Pa and tensile strength of 1.50×10^{8} Pa. The femur bone has a length of 25.0 cm and a minimum diameter of 2.50 cm.

i. What is the maximum force that can be exerted on the femur bone in the leg before fracture? **(3 marks)**

ii. If maximum compressive force is applied to the femur bone, by how much will it be shortened? **(4 marks)**

(c) A U-tube of uniform cross-sectional area, open to atmosphere, is partially filled with mercury. Water is then poured into both arms. If the configuration of the tube is as shown in Figure 4, with $h_2 = 1.00$ cm determine the value of h_1. **(9 marks)**

(d)

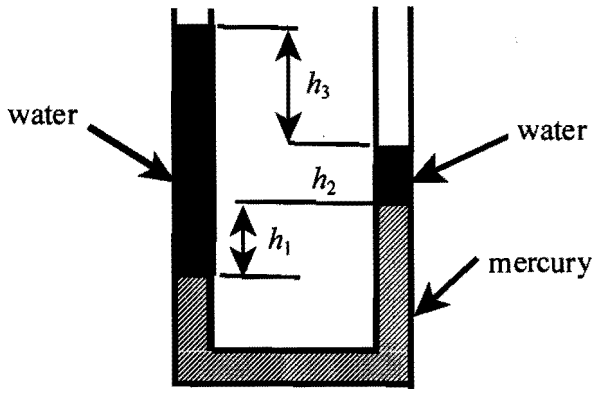

Figure 4.

QUESTION 5

(a) A spray can with a volume of 125.00 cm^3, contains gas at twice atmospheric pressure at a temperature of 22.0°C is thrown into a rubbish pit. The rubbish in the pit is then ignited and the temperature of the can rises to 195°C.

i. What is the final pressure if the volume change is neglected? **(6 marks)**

ii. The average volume of expansion coefficient for steel is $\beta = 11.0 \times 10^{-6}(°C)^{-1}$. Taking the volume change into how much different will the final pressure be (as a percent) as compared to when there is no pressure change? **(8 marks)**

(b) A 50 kg student has a fever with a temperature of 39.2 °C. The specific heat capacity of the human body is 3470 J/(kg · K) and the latent heat of vapourisation for water around this temperature is 2.42×10^6 J/kg. How much water must be sweat by the student to cool off his body to a temperature of 37.0 °C. Give the mass in kg and the volume of the water in litres. **(6 marks)**

(c) On a cold day a Level I physics student wakes up and walks from the bedroom on a carpet floor into a ceramic tile floored bathroom. The student notices that the bathroom floor feels colder than the carpet floor in the bedroom. Explain why the student feels that way. **(5 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