UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2011/2012

8

TITLE O F PAPER: INTRODUCTORY PHYSICS I

COURSE NUMBER: P101

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 the vectors $\vec{A}$ and $\vec{B}$, $\vec{A} = 3\hat{\imath} + 2\hat{\jmath} - 5\hat{k}$ and $\vec{B} = 4\hat{\imath} + 3\hat{\jmath} - 2\hat{k}$, use the dot product to find the angle between the two vectors. **(6 marks)**

(b) A body with an initial velocity of 2 m/s is accelerated at 3 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 the

i. acceleration-time **(4 marks)**
ii. velocity-time , and **(5 marks)**
iii. displacement-time graphs for this motion. **(6 marks)**

(c) A ball is headed from a height $y_0 = 2$ m and it acquires a velocity $v_0 = 15$ m/s at an angle $\theta = 40^\circ$ with the horizontal. Determine the maximum height above ground reached by the ball. **(4 marks)**

QUESTION 2

(a) Consider Figure 1 below. Let the coefficient of static friction between the blocks and the inclined surfaces be $\mu = 0.4$. The system moves such that $m_2 = 10$ kg moves up the inclined plane while $m_1 = 60$ kg moves down the inclined plane.

i. Make a resolved force diagram for each mass. **(6 marks)**

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

iii. Find the acceleration of the system. **(5 marks)**

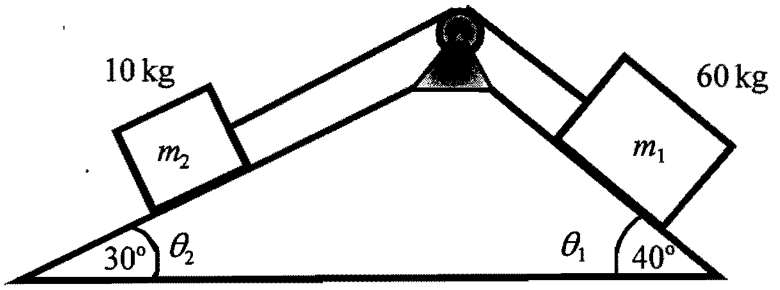

Figure 1.

(b) The system shown in Figure 2 is in equilibrium. The beam is uniform, 10 m long, and weighs 2000 N. The box of supplies of mass $m_s = 120$ kg is positioned 6 m from the pivot on the wall. Determine the

i. the tension in the cable, **(7 marks)**

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

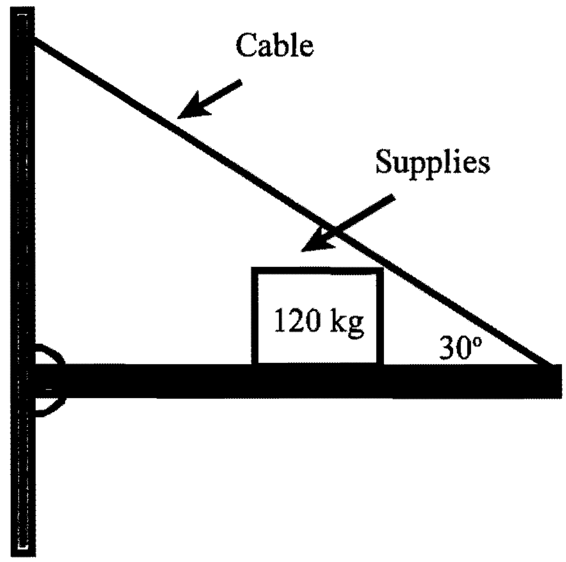

Figure 2.

QUESTION 3

(a) The system in Figure 3 is released from rest with the 40 kg block at a height $h = 8$ m above the floor. Use the principle of conservation of energy to find the velocity with which the 40 kg block hits the floor. (Neglect friction and assume that the mass of the pulley is negligible.) **(8 marks)**

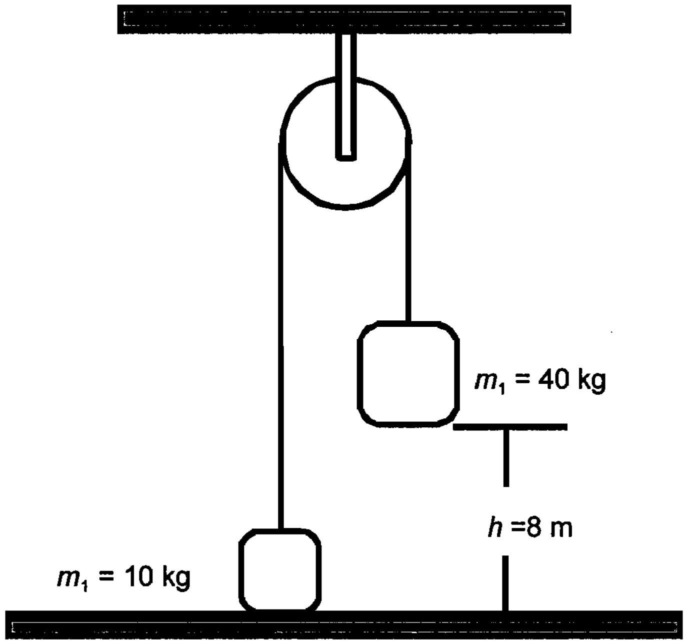

Figure 3.

(b) A bullet of mass $m = 200$ g moving with an initial speed $u_0 = 390$ m/s strikes a stationary block of mass $M = 5$ kg. The block acquires a velocity $V' = 15$ m/s after the impact.

(i) What is the final velocity of the bullet u_f? **(7 marks)**
(ii) Comment on the motion of the bullet after the impact. **(2 marks)**

(c) A flywheel of moment of inertia $I = 150$ kg m^2 is acted upon by a torque of 20 Nm from rest.

(i) What is the angular acceleration of the wheel? **(2 marks)**
(ii) What is the angular velocity of the wheel at $t = 5$ s? **(2 marks)**
(iii) What angle does it turn through in radians in the first 5 s? **(2 marks)**
(iv) What is the kinetic energy of the wheel at $t = 5$ s? **(2 marks)**

QUESTION 4

(a) The Achilles tendon of a 75 kg athlete has a cross-sectional area of 56.3 mm^2 and a length of 26.5 cm. During a high jump, the athlete exerts a force equal to 10 times his weight on the tendon and the tendon stretches by 0.634 cm. Determine

(i) the stress on the tendon, **(4 marks)**

(ii) the strain on the tendon, and **(2 marks)**

(iii)the Young's Modulus of the tendon. **(2 marks)**

(b) Explain (using physics) why it is easier to make a cut on an object with a sharp instrument than a blunt one. **(4 marks)**

(c) State Pascal's law and give one example with explanation on how it is used in every day life. **(6 marks)**

(d) A slab of wood has a thickness $t = 50$ cm, and a density $\rho_s = 650$ kg/m^3. The slab is to be used to support a load of mass $m = 540$ kg on water. What should be the minimum area of the slab of wood to just support the load? **(7 marks)**

QUESTION 5

(a) What is the temperature in °C on a day when the temperature is 98°F? **(3 marks)**

(b) Explain how a thermoflask works. **(6 marks)**

(c) A metal ball of mass $m_b = 450$ g has specific heat capacity $c_b = 650$ J/(kg·K). It is heated to a temperature $T_b = 130$°C and is then immersed in water of mass $m_w = 800$ g at a temperature $T_w = 18$°C in an insulating container. Find the final temperature reached by the system. **(8 marks)**

(d) A sealed square box container of sides $l = 30$ cm contains 4 moles of nitrogen (mass N_2 molecule = 4.68×10^{-25} kg) at a temperature of 28°C. Determine the force exerted by the nitrogen gas on the insides of the container due to the motion of the gas molecules, and explain how such a small amount of gas can exert such a large force. **(8 marks)**

GENERAL DATA SHEET

Avogadro's number $N_A = 6.022 \times 10^{23}\ mol^{-1}$
Speed of light in vacuum $c = 2.9978 \times 10^8$ m/s
Speed of sound in air = 343 m/s
Gravitational acceleration = 9.80 m/s^2
Universal gravitational constant $G = 6.67 \times 10^{-11}$ N m^2/kg^2
Density of mercury (Hg) = 1.36×10^4 kg/m^3
Density of water = 1000 kg/m^3
Standard atmospheric pressure = 1.013×10^5 Pa
Gas constant $R = 8.314$ J/(K mol)
Threshold of hearing $I_0 = 10^{-12}$ W/m^2
1 calorie = 1 c = 4.186 J
1 food calorie = 1 Calorie = 1C = 10^3 calories = 4.186×10^3 J

c_{water} = 4186 J/(kg K) c_{ice} = 2090 J/(kg K) c_{steam} = 2079 J/(kg K)
$L_{f\text{-}ice} = 3.33\text{x}10^5$ J/kg $L_{v\text{-}water} = 2.260\text{x}10^6$ J/kg

Refractive index of water $n_{water = 1.333}$
$k_e = 8.9875$ x 109 $N{\cdot}m^2/C^2$
Charge of an electron = -1.6×10^{-19} C
Charge of a proton = $+1.6 \times 10^{-19}$ C
1 atomic mass unit = 1 amu = 1 u = 1.66×10^{-27} kg
Electron mass, $m_e = 9.109 \times 10^{-31}$ kg
Proton mass, $m_p = 1.673 \times 10^{-27}$ kg
Neutron mass $m_n = 1.675 \times 10^{-27}$ kg