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UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2010/11

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 $\vec{A} = 3\hat{i} - 2\hat{j} + 2\hat{k}$ and $\vec{B} = 2\hat{i} + 2\hat{j} - 3\hat{k}$, find the angle between the two vectors. **(5 marks)**

(b) A particle starts moving from the origin with velocity of 4 m/s, and is accelerated to 12 m/s^2 for 4 s. It then moves at constant velocity for 4 s after which it is accelerated at -4 m/s^2 in 4 s. Sketch

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

(c) Water jets out of nozzle at a height y_0 =5 m above ground with a velocity v_0 = 40 m/s at an angle θ= 53° with the horizontal. Find the maximum height h above ground reached by the water jet. **(5 marks)**

QUESTION 2

(a) The system shown in Figure 1 moves such that m_1 and m_2 move towards the right while m_3 moves upward. All bodies move at a constant velocity. The coefficient of kinetic friction between all surfaces in contact is 0.2. The pulleys have negligible mass and are frictionless. The masses of the cords can be neglected.

(i) Study the system carefully and make correct force diagrams for each mass. **(6 marks)**

(ii) Write down the force equations for each mass. **(5 marks)**

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

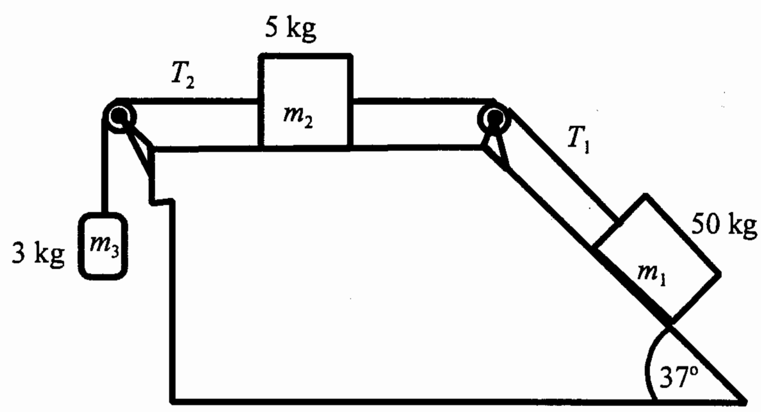


Figure 1.

(b) The system shown in Figure 2 is in equilibrium. The beam is 10 m long and weighs 200 N. The cable is attached to the middle of the beam, and makes an angle of 53o with the horizontal. The mass of 200 kg is placed on the beam à distance of 8 m from the wall.

(i) Find the tension in the cable. **(6 marks)**

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

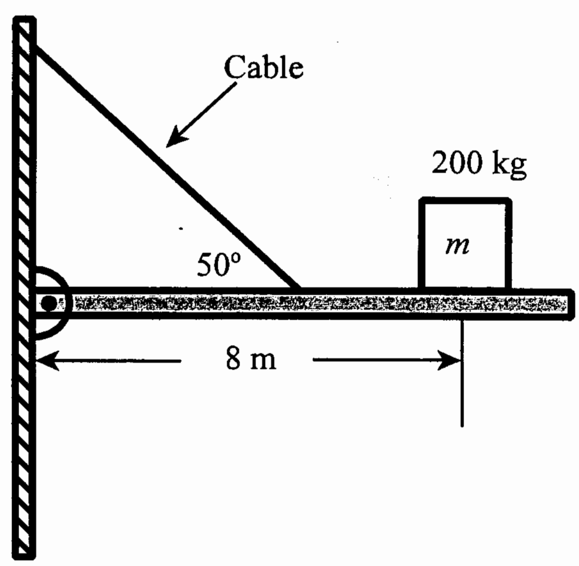


Figure 2.

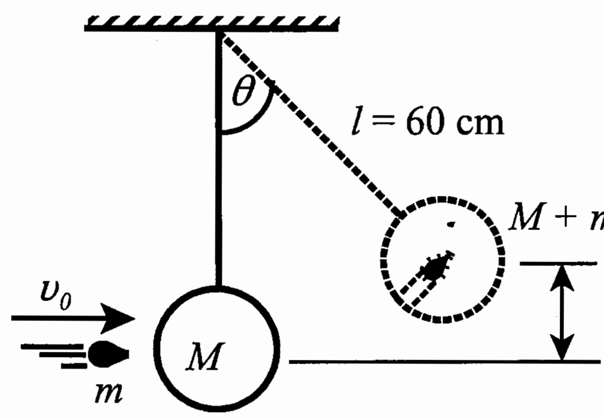
QUESTION 3

(a) In a rural clinic, water is pumped from a borehole 50 m deep into a tank with an inlet 5 m from the ground. The water is ejected with a velocity of 0.5 m/s at a rate of 2 litres per minute.

(i) How much potential energy is given to the water per minute? **(2 marks)**
(ii) How much kinetic energy is given to the water per minute? **(2 marks)**
(iii) What is the power of the pump? **(2 marks)**
(iv) For how long will the pump be operated to fill a 5000 litre tank? **(1 mark)**
(v) How much would it cost to fill the tank if electricity costs 94 cents per kilowaat-hour? **(2 marks)**

(b) A bullet of mass $m = 80$ g is shot at a suspended ball of mass $M = 8$ kg. After the collision, the cord of length $l = 60$ cm suspending the mass is swung over a maximum angle $\theta = 40°$. See Figure 3.

(i) What is the maximum potential energy gained by the ball and bullet? **(2 marks)**
(ii) What was the velocity of the ball and bullet just after impact? **(2 marks)**
(iii) Find the original velocity of the bullet v_0. (***his part requires the use of momentum***) **(4 marks)**



(c) A flywheel of moment of inertia $I = 125$ kg m^2 is under a torque of 5 Nm.

(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 in radians does it turn through in the first 5 s? **(2 marks)**
(iv) What is the kinetic energy of the wheel at $t = 5$ s? **(2 marks)**

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QUESTION 4

(a) Sketch a stress-strain diagram for a ductile metal and label all its parts. **(5 marks)**

(b) A circular metal wire of cross-sectional are A = 7.85×10^{-7} m^2, and a length of 2.5 m supports a load of 15 kg within the proportional region. The Young's modulus for the wire is 5.688×10^{10} N/m^2.

(i) What is the stress on the wire? **(2 marks)**
(ii) What is the strain on the wire? **(2 marks)**
(iii) By how much does the wire stretch under the load? **(2 marks)**

(b) A slab of certain material of area A has a thickness t = 20 cm and density ρ_s = 650 kg/m^3. The slab is used to support a load of mass m = 500 kg on fresh water. What should be the area of the slab if it floats with one side of area A coinciding with the water level? **(6 marks)**

(c) A sealed tank contains water for a fire hydrant to a level of 12 m. Above the water level there is pressurised air at a pressure of 10 atmospheres. 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)**

QUESTION 5

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(a) Discuss how a thermoflask reduces heat transfer between its contents and the surroundings. **(6 marks)**

(b). A metal ball of mass $m_b = 250$ g at a temperature of 120°C is placed in an insulated copper calorimeter of mass $m_c = 200$ g, containing water of mass $m_w = 400$ g, at a temperature of $T_0 = 20$°C. The final temperature reached by the system is 25°C. Determine the specific heat capacity of the metal ball. Let the specific heat of copper be 387 J/(kg K). **(8 marks)**

(c) From the definition of energy and work, discuss why you would consider heat to be a form energy. **(5 marks)**

(d) A tank contains a gas at a pressure of 5 atmospheres at a temperature of 25°C. The tank is heated so that the pressure rises to 20 atmospheres. What is the final temperature reached by the gas in the tank? **(6 marks)**

GENERAL DATA SHEET

Speed of light in vacuum, $c = 2.9978 \times 10^8$ m/s
Speed of sound in air = 334 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 = 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)
Avogadro's number, $N_A = 6.022 \times 10^{23}$ mol^{-1}
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
Specific heat capacity for water, $c_w = 4186$ J/(kg K)
Specific heat capacity for ice, $c_i = 2090$ J/(kg K)
Specific heat capacity for steam, $c_s = 2079$ J/(kg K)
Latent heat of fusion for ice, $L_f = 3.33 \times 10^5$ J/kg
Latent heat of vapourisation for water $L_v = 2.260 \times 10^6$ J/kg
Coulomb's constant, $k_e = \dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9$ Nm^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