UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE
FAKULTEIT NATUURWETENSKAPPE

DEPARTMENT OF PHYSICS /DEPARTEMENT FISIKA

MODULE: **PHY1A3E**

CAMPUS **APK**

EXAM **11 JUNE 2016**
DAY **SATURDAY (8:30 a.m)**

EXAMINER **DOOMNULL UNWUCHOLA**

MODERATOR **Prof. CA ENGELBRECHT**

DURATION 165 min* **MARKS 142**

THIS PAPER CONSISTS OF 7 PAGES INCLUDING THE COVER PAGE

INSTRUCTIONS: Answer ALL questions

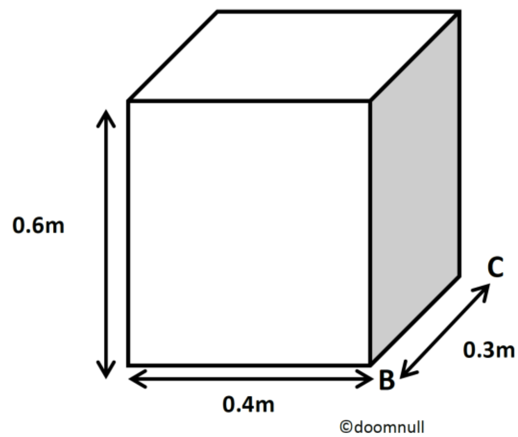
QUESTION 1 follows /…

Question 1 [21]

1.1

A cube rests on a rough plane, the coefficient of friction between the cube and the plane is 0.82. Using detailed diagrams and proofs, show If the cube will topple first or slide first, if the angle the plane makes with the horizontal is increased? (5)

1.2



A uniform rectangular block of density 850 kg/m^3 rests on a horizontal table. Calculate:

1.2.1 the least force necessary to start it tilting about the edge **BC**; (4)
1.2.2 through what angle can it be tilted before toppling over. (3)

1.3. A uniform ladder of mass **m** and length ***l*** making an angle **θ** with the horizontal stands on a rough floor, with coefficient of friction μ, and leans against a smooth wall. Show that the force due to friction, $\mathbf{F_f}$, on the foot of the ladder is given by:

$$\mathbf{F_f} = \mathbf{mg}/(\mathbf{2tan\theta}). \qquad (5)$$

1.4 A force F is required to stretch a wire of circular cross-section by an amount Δ*l*. The wire is now melted down and a new wire (also of circular cross-section) is formed that has five times the length of the first. What force expressed in terms of F is needed to stretch the second wire by the same amount Δl? (4)

Question 2 [31]

2.1 Waves transport energy through a string as they propagate. Each element of the string of length dx and mass dm is a simple harmonic oscillator and therefore has kinetic energy and potential energy associated with it. It is known that the elements oscillate in the vertical direction, with displacement given by $y = A \sin (kx - \omega t)$, and the transverse speed, $v_y = - \omega A \cos (kx - \omega t)$. Stating all assumptions and integrating over all the string's elements in a wavelength of the wave, show that:

2.1.1 the total kinetic energy K in one wavelength is

$$K = \frac{1}{4} \mu\omega^2 A^2\lambda$$ (9)

2.1.2 the total potential energy U in one wavelength is (9)

$$U = \frac{1}{4} \mu\omega^2 A^2\lambda$$

2.1.3 the power P or the energy during a time interval of one period of oscillation T associated the mechanical wave is

$$P = \frac{1}{2} \mu\omega^2 A^2 v$$ (3)

Where μ is the mass per unit length and v is the speed of propagation.

2.2 An organ pipe open at both ends has a fundamental frequency of 440Hz. Its second harmonic has the same frequency as the third harmonic of another organ pipe which is open at one end and closed at the other. Calculate the length of each pipe.
(Speed of sound in air = 340 m/s). (5)

2.3 A person produces a note at a frequency of 250 Hz in dry air. What would the frequency of the same voice vibration be if he filled his lungs with hydrogen?
(Molar mass of dry air = 29 g/mol and molar mass of hydrogen = 2 g/mol). (5)

Question 3 [27]

3.1 A block of 0.35kg connected to a light spring, for which the force constant is 8 N/m, is free to oscillate on a frictionless, horizontal surface. The block is displaced 0.09 m from equilibrium and released with an initial velocity of V = -0.28 m/s. Calculate

3.1.1 the angular frequency ω and the period T of system, (2)

3.1.2 the phase constant Φ, (3)

3.1.3 the amplitude A of the system, (1)

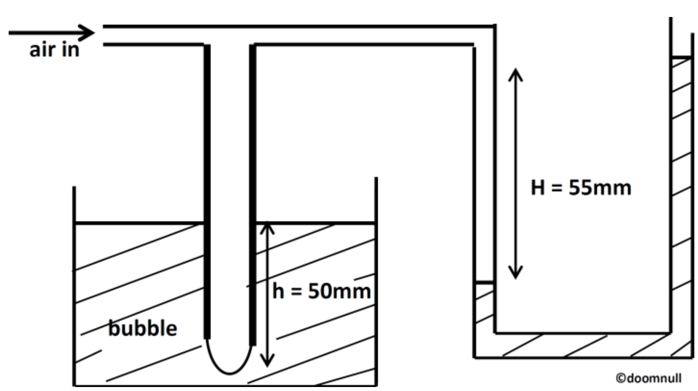
3.1.4 the maximum speed of the block, (1)

3.1.5 the maximum acceleration of the block. (1)

3.2 A crystal soluble in water has a mass of 15.96 g in air and an apparent mass of 10.53 g in oil in which it is soluble. A certain sinker has a mass 11.68 g in air, an apparent mass of 1.72 g in water, and an apparent mass 3.81 g in the above-mentioned oil. Calculate the density of the crystal.
(Given: density of water = 1000 kg/m^3) (8)

3.3 If a boy can lift a 15 kg piece of granite in air, what mass of granite could he lift from the bottom of a swimming pool.
(Density of granite = 2700 kg/m^3). (5)

3.4.



The sketch shows an apparatus for measuring surface tension. When air is blown into the apparatus, bubbles are emitted from the end of the tube, which is at a depth **h** below the surface of the water. The radius of the tube is 2.5mm. The pressure is measured with the U-tube containing water, shows a difference in levels of **H**, when the bubble is exactly hemispherical and about to break away. Calculate the surface tension of water. (6)

Question 4 [40]

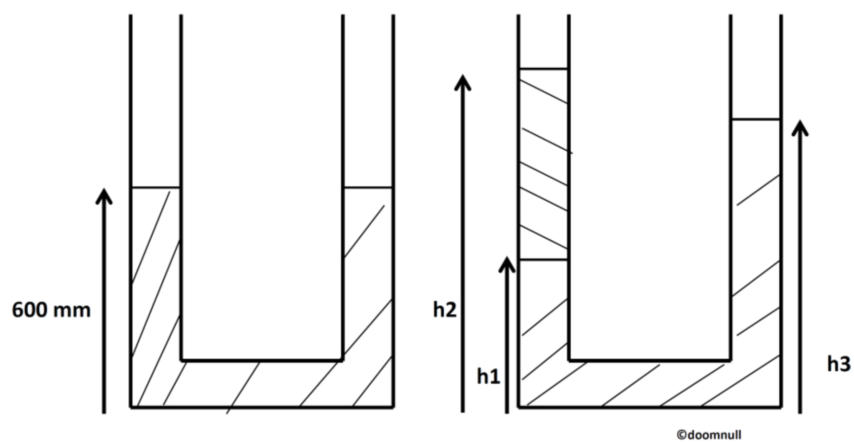
4.1 A nitrogen bubble with diameter $\mathbf{d_1}$ = 2 μm forms in the tissue of a diver 100 m below the surface of the sea. Show that the diameter **d** when it reaches the surface can be calculated from the cubic equation.

$$\mathbf{d}^3 + 2.88 \times 10^{-6}\mathbf{d}^2 - 9.95 \times 10^{-17} = 0.$$

(Given: $P_{atm} = 10^5$ Pa; surface tension of tissue fluid = 0.072 J/m^2).

(10)

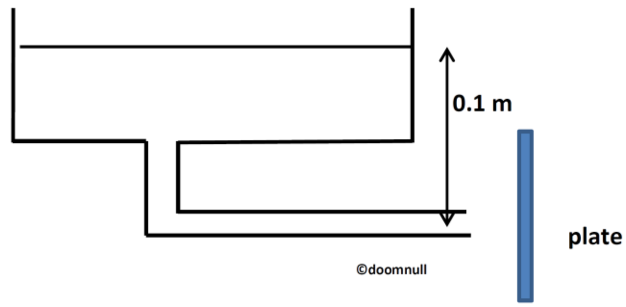
4.2



A U- tube of internal cross-sectional area 10 mm^2 contains water as shown in the diagram. A volume of 10^3 mm^3 of oil of density 800 kg/ m^3 is introduced into the left arm of U-tube. No mixing takes place and the system comes to equilibrium. Calculate the height of the three interfaces, $\mathbf{h_1}$,$\mathbf{h_2}$ and $\mathbf{h_3}$.

(6)

4.3



Water flows out of a tank through a tube 5 mm in internal diameter and is discharged horizontally, striking a vertical plate. The outlet is 0.1 m below the free surface of the water, and the cross-sectional area of the tank is extremely large compared with that of the tube. Calculate:

4.3.1 the velocity with which the water emerges from the end of the tube, (4)

4.3.2 the force that the water exerts on the plate, if the water has no horizontal component of velocity after the impact. (4)

4.4 Two copper spheres of equal mass are attached to strings of length 1m and suspended from the same point on the ceiling. Both spheres are drawn apart until each string is at 45^o to the vertical, and then simultaneously released. After the collision, the maximum angle each string makes with the vertical is 30^o. Assuming that 90 % of the energy lost is converted into heat; calculate the temperature rise of each sphere.
(Given: Specific heat of copper = 390 $Jkg^{-1o}C^{-1}$; g = 10 ms^{-2}) (8)

4.5 A lead bullet travelling at 350 m/s strikes a target and is brought to rest. The bullet is initially at 27^oC and 20% of the heat is lost from it. What fraction of the bullet melts?
Given: Specific heat of lead = 130 $Jkg^{-1o}C^{-1}$.
Latent heat of fusion of lead = 2.5×10^4 Jkg^{-1} . (8)
Melting point of lead = 327^oC.

Question 5 [23]

5.1 A person's body temperature must be maintained at 37^oC. When he exercises his body produces heat at a rate of 120W. If his body radiates and absorbs energy like a black body, and if the only other process through which it loses energy is through sweating, calculate how many litres of water must be drunk each hour in order to prevent dehydration. His surface area is 1.5 m^2 and the surroundings are at 27^oC. (Given: The latent heat of sweat = 2.5 x 10^6 Jkg^{-1} and the density of sweat is 10^3 kg/m^3). (8)

5.2 A pendulum made of magnesium wire with a massive bob on the end has a period of 1s at 10^oC. Calculate the change in the period when the temperature rises to 40^oC.
(Given: Coefficient of linear expansion of magnesium = 2.5 X 10^{-5} $^oC^{-1}$). (6)

5.3 An aluminium spray can has a 2000 cm^3 capacity at 0 ^oC. The spray can is filled with 800 cm^3 of liquid and 1200 cm^3 of nitrogen at 1 atmosphere, also at 0 ^oC. If the can with its contents is heated to a 1000 ^oC, calculate the pressure (in atm) of the nitrogen inside the can, taking account the thermal expansion of both the aluminium can and the liquid. Assume that no phase transitions occur.
(Given: α_{Al} = 24 X 10^{-6}, β_{liquid} = 9 X 10^{-4} $^oC^{-1}$ and 1 atm = 10^5 Pa) (9)

END