PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF APPLIED PHYSICS

SEMESTER ONE EXAMINATION, 2022

AP111: INTRODUCTORY PHYSICS I

Date: Tuesday 7th June, 2022

Time: 0820 HOURS

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS

1. You have **TEN MINUTES** to read this question paper. Do not begin writing during this time.
2. **Questions 1 and 2 are COMPULSORY**; you **MUST** ANSWER THESE TWO QUESTIONS. From questions 3 to 10, **ANSWER ANY THREE (3) QUESTIONS OF YOUR CHOICE.** Each question carries an equal **mark of 20: (Total mark = 5 x 20 =100)**
3. All answers must be written on the Answer Booklet provided.
4. **COMPLETE THE DETAILS REQUIRED ON THE FRONT COVER OF THE ANSWER BOOKLET. DO THIS NOW**
5. Complete details on Attendance Slip. **DO THIS NOW**
6. Calculators are permitted in the examination room. Textbook, notebooks and mobile phones are NOT permitted.

QUESTION 1

I. **i)** Name any three *basic quantities* and state their *SI units*.
ii) Name any three *derived quantities* and state their *SI units*. **[6 marks]**

II. How many significant figures are there in the following figures?
(i) 0.000350
(ii) 580000
(iii) 2.000×10^2 **[3 marks]**

III. Convert the following;
i) $0.002m^3$ to cm^3
ii) 10 rpm to $rads^{-1}$ **[4 marks]**

IV. The period T of a simple pendulum in Fig.1 should intuitively depend on the length (l) of the rope, mass (m) of bob, angle (θ) subtended from the vertical and gravitational acceleration (g). Derive the relationship via dimensional analysis. **[7 marks]**

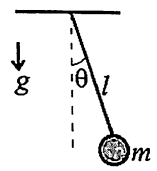

Fig. 1

QUESTION 2

I. A marathon runner runs 6 km north east, then turns south and runs for 10 km and finally 2 km at a bearing of 40^0 west of north. Find the magnitude and direction of the runner's resultant displacement using the components method. **[9 marks]**

II. In an experiment, the height and radius of a cylindrical prism are measured to be $h = 20.23 \pm 0.01$ cm and $r = 10.15 \pm 0.01$cm, respectively. Calculate the volume of the prism and its absolute error. **[5 marks]**

III. The velocity of a racing car as a function of time is given by $\vec{x}(t) = (\alpha t^3)\hat{\imath} + (\beta t^2)\hat{\jmath}$ where $\alpha = 0.04\ ms^{-3}$ and $\beta = 0.5\ ms^{-2}$. Determine the magnitude and direction of the total acceleration vector of the racing car at $t = 2s$. **[6 marks]**

QUESTION 3

I. Beginning from rest, a PMV truck is accelerated at $0.5\ ms^{-2}$ for 2 minutes. The speed is then kept constant for another 2 minutes after which it is decelerated to rest. If the total time taken for the entire journey is 7 minutes;
i) plot v-t graph depicting the entire motion (with numerical values of v and t)
ii) calculate the deceleration
iii) determine the total distance travelled for the entire journey. **[10 marks]**

II. A student throws a set of keys vertically upward to a friend on the first floor 5 m above. The keys are caught 2.50 s later by the friends' outstretched hands. Determine
i) the initial velocity with which the keys were thrown.
ii) the velocity of the keys just before they were caught.
iii) whether the keys were caught on the upward or return journey. **[6 marks]**

III. A car travelling along a straight road at 10 ms^{-1} goes off a cliff 50 m high. Calculate how far away from the base of the cliff the car will land. **[4 marks]**

QUESTION 4

I. State Newton's three Laws of motion. **[6 marks]**

II. Consider the system given in *Fig.2* in which $\alpha = 40^{\circ}$, $m_1 = 6$ kg, $m_2 = 8$ kg and the coefficient of kinetic friction between m_1 and the surface is 0.3. When the system is released, m_2 accelerates downward. Find;

i) the tension T in the cable and

ii) the acceleration of m_2 **(14 marks)**

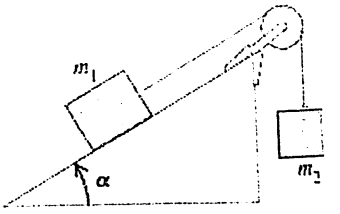

Fig. 2

QUESTION 5

I. Derive the *work-energy theorem* relating total work done by a net force to change in kinetic energy of an object. **[4 marks]**

II. A 35-kg crate is pushed downward at an angle of 40^0 below the horizontal at *constant velocity*. The coefficient of kinetic friction between the crate and the floor is 0.25.

i) How much work is done by the applied force when the crate is displaced 6.0 m?

ii) How much work is done by friction during this displacement?

iii) How much work is done by gravity and the normal force?

iv) What is the total work done on the crate? **[8 marks]**

III. Fig. 3 shows the path of a stone of mass 0.80 kg after being thrown from a point A with a velocity of 50 ms^{-1} at an angle of 60° to the horizontal. Find;

i) the total energy of the stone at A just as it leaves.

ii) its potential energy at B

iii) its speed at C just before impact.

iv) the angle to the horizontal at which the stone hits the ground. **[8 marks]**

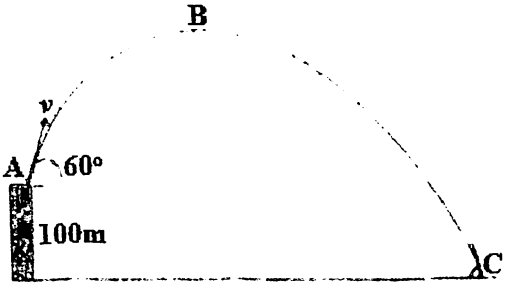

Fig. 3

QUESTION 6

I. Consider a particle acted on by a constant net force ($\sum \vec{F}$) in a time interval Δt. Derive the *Impulse-Momentum theorem* that relates impulse, $\vec{J}$, to the change in momentum ($\Delta \vec{p}$) of the particle. **[4 marks]**

II. A small wooden block of mass 1.0 kg is suspended from lower end of a light cord and at rest. A bullet with mass 15.0 g, fired at the block with a horizontal velocity, v_o, strikes the block,

becomes embedded in it and the combined mass swings on the end of the cord and rises a vertical height of 0.800 m. Find v_o of the bullet. **[8 marks]**

III. Flywheel of an engine of radius r = 0.3 m having moment of inertia of 6.0 kgm^2 starts from rest and accelerates with constant angular acceleration to an angular velocity of 60 rad/s in 10 s. Find the

i) angular acceleration
ii) constant net torque on the flywheel
iii) the angle through which the flywheel has turned during this time.
iv) final kinetic energy of the flywheel.
v) Magnitude of total acceleration at the 10 s mark. **[8 marks]**

QUESTION 7

I. With aid of diagrams showing orientation of forces on an object under stress, define Young's, Shear and Bulk moduli. **[6 marks]**

II. Consider the steel plate shown in *Fig. 4*. If the shear force of magnitude 5 x 10^5 N is applied as shown, find;

i) the resulting shear strain
ii) the displacement x **[5 marks]**

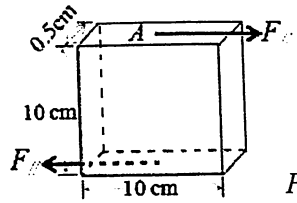

Fig. 4

III. **i)** State *Archimedes' Principle*

ii) An ore sample weighs 20 N in air. When the sample is suspended by a rope and totally immersed in water, the tension in the rope is 15.4 N. Find the total volume and the density of the sample. **[9 marks]**

QUESTION 8

I. State *Pascal's Law* **[2 marks]**

II. There is evidence that Mars may once have had an ocean 0.5 km deep. The acceleration due to gravity on Mars is 3.71 ms^{-2}. Compute

i) gauge pressure at the bottom of such an ocean, assuming it was fresh water.
ii) the depth to which you need to go in the earth's ocean to experience the same gauge pressure. **[4 marks]**

III. A water sprinkler system discharges water from a horizontal pipe at the rate of 8200 cm^3/s. At one point in the pipe where the radius is 6.00 cm, the water's absolute pressure is 3 x 10^5 Pa. At a second point in the pipe, the water passes through a constriction where the radius is 3.00 cm. Compute absolute pressure of water through the constricted section. **[8 marks]**

IV. A small circular hole 6.00 mm in diameter is cut in the side of a large water tank, 14.0 m below the water level in the tank. The top of the tank is open to the air. Find;

i.) the speed of efflux of the water and
ii.) the volume of water that would be discharged per second. **[6 marks]**

QUESTION 9

I. The position of a 0.500-kg mass attached to a spring undergoing SHM is described by

$$x(t) = (3.6cm)cos[(10\pi s^{-1})t - \pi/4]$$

Determine the;

(a) period
(b) amplitude of oscillation
(c) spring constant
(d) maximum speed of the mass (and where it occurs)
(e) maximum acceleration of the mass (and where this occurs)
(f) position and velocity of the mass at t = 1.00 s
(g) maximum restoring force on the mass and
(h) total mechanical energy in the system. **[10 marks]**

II. Distinguish between longitudinal and transverse waves. **[2 marks]**

III. A transverse wave travelling to the left on a string has following attributes; amplitude = 4.0 cm, frequency = 100 Hz and wavelength = 2.0 cm. Write down the equation describing the displacement of the string as a function of position and time. **[4 marks]**

IV. Standing waves produced on a guitar string have the following parameters; amplitude of the standing wave = 10 cm, angular frequency = 942 rad/s, and wave number = 0.750π rad/m. The left end of the wire is at $x = 0$.

a) write the equation for the standing wave as a function of position and time
b) the first two positions of the nodes on the standing wave
c) the first two positions of the antinodes on the standing wave. **[4 marks]**

QUESTION 10

I. Define *thermometric property* of a substance. For the mercury-in-glass thermometer, identify the thermometric substance and the thermometric property. **[4 marks]**

II. A thermometer operating on the basis of variation of electric resistance with temperature gives the following readings on the ideal Celsius scale;

Resistance (ohms)	1.5	2.06	1.9
Temp (°C)	0	100	X

Determine the temperature X in °C scale corresponding to 1.9 ohms on resistance scale. **[4 marks]**

III. A copper calorimeter with a mass of 0.1 kg contains 0.15 kg of water and 0.012 kg of ice at atmospheric pressure. If 0.6 kg of lead at 200°C is dropped into the calorimeter, what is the final temperature of the mixture assuming that no heat is lost to the surroundings? **[6 marks]**

IV. Name the three *mechanisms of heat transfer* and write short notes about how energy is transferred via these mechanisms. **[6 marks]**

.....End of Exam.....