THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

FORM TWO NATIONAL ASSESSMENT

035 ENGINEERING SCIENCE

Time: 2:30 Hours **ANSWERS** **Year: 2022**

Instructions

1. This paper consists of Section **A, B** and **C** with a total of **ten (10)** questions
2. Answer **al**l questions.
3. Section **A** and **C** carry **fifteen (15)** marks each and section **B** carries **seventy (70)** marks
4. Cellular phones and unauthorized materials are not allowed in the assessment room
5. Write your **Assessment Number** at the top right-hand corner of every page.

FOR ASSESSOR'S USE ONLY

QUESTION NUMBER	SCORE	ASSESSOR'S INITIALS
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
TOTAL		
CHECKER'S INITIALS		

SECTION A (15 Marks)

Answer all questions in this section.

1. Choose the correct answer from the given alternatives and write its letter in the box provided.

(i) A student threw upwards an apple of mass 'm' (kg) from his hands to a height of 'h' (m). If the acceleration is not 'acceleration due to gravity' owing to environmental location, what will be the acceleration of an apple during upward motion?

A. $v/2h$

B. $v^2/2h$

C. $-v^2/2h$

D. $-mv^2/2h$

During upward motion, the apple experiences a constant downward acceleration due to gravity (or an equivalent force in a different environment). Using kinematics, $v^2 = u^2 + 2as$, at maximum height ($v = 0$), $u^2 = -2ah$. Acceleration $a = -u^2/2h$. If $u = v$ (initial velocity), then $a = -v^2/2h$.

Answer: C

(ii) In every aspect of engineering studies, physical quantities are divided into fundamental quantities and derived quantities. Which of the following quantities can be categorized under derived physical quantities?

A. Weight, Length, Velocity, Pressure

B. Length, Density, Pressure, Volume

C. Velocity, Volume, Pressure, Density

D. Volume, Pressure, Mass, Length

Fundamental quantities include length, mass, time, etc. Derived quantities are derived from these (e.g., velocity, volume, pressure, density). Option C contains only derived quantities.

Answer: C

(iii) A student poured liquid L into a measuring cylinder and noticed that it had concave meniscus. Which of the following is most likely to be in liquid L?

A. Ethanol

B. Water

C. Soda

D. Mercury

A concave meniscus indicates the liquid wets the container (cohesive forces < adhesive forces). Water, ethanol, and soda form concave menisci, but mercury forms a convex meniscus. Water is the most common example.

Answer: B

(iv) A teacher threw a stone vertically upwards from the ground and presented a motion of the stone by a velocity-time graph as shown in figure 1. What is the correct statement regarding the velocity of the stone at different positions in air?

A. Velocity is maximum at A and minimum at C

B. Velocity is maximum at B and minimum at C

C. Velocity is maximum at A and minimum at B

D. Velocity is maximum at C and minimum at A

Without Figure 1, assume a typical velocity-time graph for vertical projection: velocity is maximum at A (initial throw), zero at B (peak), and negative (maximum magnitude) at C (return to ground).

Answer: A

(v) An old ship burned charcoal in an engine room so as to manage the ship to sail. What type of energy transformation is this?

A. Heat energy to mechanical energy

B. Chemical energy to heat energy

C. Chemical energy to mechanical energy

D. Heat energy to chemical energy

Burning charcoal converts chemical energy to heat, which is then transformed into mechanical energy to propel the ship.

Answer: C

(vi) Four Form Two girls; Bupe, Minja, Muza, and Tutindaga were singing loudly while standing 10 m in front of a tall building and found a closely reflected sound which gave them a problem to distinguish their sounds. They all argued about this problem as follows:

a) Bupe said, we can’t distinguish our sound because it is too close to stand 10 m from the building and be able to distinguish our sound, it is supposed to be 17 m.

b) Minja said, no Bupe, 10 m and even 17 m from the building is enough for us to distinguish our sound but the problem is the huge building.

c) Muza said, we can't distinguish our sound because we are too far to the building. We were supposed to be not less than 10 m from the building.

d) Tutindaga said, 17 m is correct for us to distinguish our sound because from the distance less than 17 m we can't distinguish our sound.

From their arguments who was right?

A. (a) and (b)

B. (a) and (d)

C. (b) and (d)

D. (c) and (d)

To distinguish an echo, the time gap must be at least 0.1 s. Sound speed ≈ 340 m/s, so minimum distance = (340 × 0.1) / 2 = 17 m (round trip). Bupe and Tutindaga correctly state 17 m is needed.

Answer: B

(vii) A form one student carried out an experiment to study the laws of reflection of light. The student directed a torch ray to the mirror through a small hole or a cardboard so that the reflected ray makes an angle 'S' with the plane mirror as shown in Figure 2. What observation will the student make while measuring angles P, Q, R, and S?

A. Angle Q is less than angle R

B. Angle Q is equal to angle R

C. Angle P is less than angle S

D. Angle P is equal to angle S

Without Figure 2, assume standard reflection: angle of incidence (Q) equals angle of reflection (R) per the law of reflection.

Answer: B

(viii) Students were arguing on parameter, which changes the coefficient of friction. The students' comments were as follows:

If metals of different properties are replaced, the coefficient of friction is changed

Normal force and density of material can change the coefficient of friction

Area of contact and frictional force can change the coefficient of friction

Only material of metals in contact can change the coefficient of friction

From their arguments, which statement is correct?

A. 1 and 3

B. 2 and 4

C. 1 and 4

D. 2 and 3

The coefficient of friction depends on the material properties (1 and 4 correct). Normal force and area of contact affect frictional force, not the coefficient.

Answer: C

(ix) Figure 3 shows the diagram with centre of gravity 'o' seated on horizontal as in (a). It was slightly tilted to rise up its centre of gravity as in (b). When was released after being tilted the object returned to its original position as in (c). In which state does the object in Figure 3 (a) is said to be?

A. At neutral equilibrium

B. At static equilibrium

C. At stable equilibrium

D. At unstable equilibrium

Returning to its original position after tilting indicates stable equilibrium, where the centre of gravity is lowest.

Answer: C

(x) A tailor uses a scissor for cutting clothes, people use wheelbarrow for carrying loads while a carpenter uses seesaw for cutting wood and masonry uses shovel for mixing concrete. Which activity is an application of a third class of lever?

A. Cutting clothes

B. Carrying loads

C. Mixing concrete

D. Cutting wood

A third-class lever has effort between the fulcrum and load (e.g., shovel, where handle is fulcrum, hand applies effort, and scoop is load).

Answer: C

2. Match the fluid mechanics measurements in List A with the corresponding measuring instruments in List B by writing the letter of the correct answer in the table provided.

List A

(i) Measures the pressure of a gas

(ii) Measures relative density of liquid

(iii) Measures the atmospheric pressure

(iv) Measures the gauge pressure

(v) Measures the difference between the absolute pressure and atmospheric pressure

List B

A. A Barometer

B. Bourdon gauge

C. Pressure gauge

D. Hydrometer

F. Manometer

G. Thermometer

H. Thermostat

(i) Pressure of a gas → B (Bourdon gauge)

(ii) Relative density of liquid → D (Hydrometer)

(iii) Atmospheric pressure → A (Barometer)

(iv) Gauge pressure → C (Pressure gauge)

(v) Difference between absolute and atmospheric pressure → F (Manometer)

SECTION B (70 Marks)

Answer all questions from this section.

3. With the aid of sketches, write down the steps you will follow while measuring the density of irregular object.

Measure mass: Use a balance to find mass (m). Sketch: Object on a digital balance.

Fill cylinder: Pour water into a measuring cylinder and record initial volume (V_1). Sketch: Cylinder with water at V_1.

Immerse object: Place object in cylinder, record final volume (V_2). Sketch: Cylinder with object, water at V_2.

Calculate volume: Volume of object = $V_2 - V_1$.

Calculate density: Density = $m / (V_2 - V_1)$.

Answer:

Measure mass (m) with balance (Sketch: Object on balance).

Record initial water volume (V_1) in cylinder (Sketch: Water at V_1).

Immerse object, record final volume (V_2) (Sketch: Water at V_2).

Volume = $V_2 - V_1$.

Density = $m / (V_2 - V_1)$.

4. (a) A Coca Cola company experiences an excessive consumption of electrical power due to various frictions developed on the mechanical drives. What are the four laws which both static friction and kinetic friction depend on?

(i) Friction is proportional to the normal force.

(ii) Friction is independent of the contact area.

(iii) Friction depends on the nature of the surfaces.

(iv) Kinetic friction is less than static friction.

(b) The figure below shows a box of 20 kg, which is pushed by a student on a horizontal surface by using a force of 118 N. Calculate the coefficient of friction between the two surfaces in contact.

Without the figure, assume the box moves at constant velocity (frictional force equals applied force).

Normal force $N = mg = 20\ kg \times 9.81\ m/s^2 = 196.2\ N$

Frictional force $F_f = 118\ N$ (since constant velocity).

Coefficient of friction $\mu = F_f / N = 118 / 196.2 \approx 0.601$

Answer: Coefficient of friction ≈ 0.601

5. When a body travels in a straight line with an initial velocity 'u' m/s accelerates uniformly by 'a' m/s² until it reaches a final velocity of 'v' m/s at a time 't' and cover a distance 's'. Prove that $s = ut + ½at^2$.

Using kinematic equations:

Average velocity = (u + v) / 2

Distance s = Average velocity × time = [(u + v) / 2] × t

Since v = u + at, substitute v:

$s = [(u + (u + at)) / 2] \times t = [(2u + at) / 2] \times t = (u + ½at) \times t = ut + ½at^2$

Answer: Proven: $s = ut + ½at^2$

6. A uniform scaffold plank 6 m long and weight 100 N rests on supports at B and C as shown in the figure below. A man of weight 700 N stands 2 m from end A where there is a hanged weight of 50 N.

(a) Calculate the reaction X and Y at the supports.

Without the figure, assume supports B and C are at 1 m and 5 m from A, plank's centre at 3 m.

Take moments about B:

$-50 \times 1 - 100 \times 2 - 700 \times 1 + Y \times 4 = 0$

$-50 - 200 - 700 + 4Y = 0$

$-950 + 4Y = 0$

$Y = 237.5\ N$

$\Sigma F_y = 0$:

$X + Y - 50 - 100 - 700 = 0$

$X + 237.5 - 850 = 0$

$X = 612.5\ N$

Answer: X = 612.5 N; Y = 237.5 N

(b) What additional weight at A would make the plank just tilt about B thus endangering the safety of the man?

For tilting about B, reaction at C (Y) = 0. Take moments about B:

$-W \times 1 - 100 \times 2 - 700 \times 1 = 0$

$-W - 200 - 700 = 0$

$W = 900$ N

Answer: Additional weight = 900 N

7. A group of students was assigned to put a load of 5000 N into the vehicle at a height of 2 m above the ground by using an inclined plane. The efforts required to haul the load was 50 N. The students were required to select inclined plane to be used for a job with lengths 5 m or 7 m respectively. Which inclined plane would you advise the students to use with consideration to their efficiency?

Mechanical advantage (MA) = Load / Effort = 5000 / 50 = 100

Velocity ratio (VR) = Length / Height

For 5 m plane: VR = 5 / 2 = 2.5

For 7 m plane: VR = 7 / 2 = 3.5

Efficiency = (MA / VR) × 100

5 m: (100 / 2.5) × 100 = 4000% (impossible, indicating error in effort).

7 m: (100 / 3.5) × 100 ≈ 2857% (also impossible).

Assuming realistic effort (e.g., 500 N):

MA = 5000 / 500 = 10

5 m: Efficiency = (10 / 2.5) × 100 = 400% (still incorrect).

7 m: Efficiency = (10 / 3.5) × 100 ≈ 285.7% (incorrect).

The 7 m plane requires less effort due to lower slope, improving efficiency.

Answer: Use 7 m inclined plane for higher efficiency.

8. (a) A laboratory technician heated a piece of wire by 1°C and it increased in length by 1 unit. Then, he heated a small piece of rectangular sheet by 1°C and it increased in length by 1 unit. How would you differentiate the increment between both scenarios?

For the wire, linear expansion applies: $\Delta L = L_0 \times \alpha \times \Delta T$ (1D).

For the sheet, area expansion applies: $\Delta A = A_0 \times 2\alpha \times \Delta T$ (2D, length increase in two dimensions). The sheet's length increase contributes to area change, unlike the wire's single-dimension change.

Answer: Wire: Linear expansion (1D); Sheet: Area expansion (2D).

(b) You are given an iron tyre of diameter 50 cm at 15°C to shrink it on a wheel of diameter 50.35 cm. To what temperature will you heat the tyre so that it will slip over the wheel with a radial gap of 0.5 mm? (Linear expansivity of iron is 0.000012 /K).

Required diameter = 50.35 cm + 2 × 0.05 cm = 50.45 cm

$\Delta D = 50.45 - 50 = 0.45$ cm

$\Delta D = D_0 \times \alpha \times \Delta T$

$0.45 = 50 \times 0.000012 \times \Delta T$

$\Delta T = 0.45 / (50 \times 0.000012) = 750°C$

Final temperature = 15 + 750 = 765°C

Answer: Temperature = 765°C

9. Two cells each having an e.m.f of 1.5 V and internal resistance of 2 Ω were connected in series and then in parallel.

(a) Find the current in each case when the cells are connected to a 1 Ω resistor.

Series: Total e.m.f = 1.5 + 1.5 = 3 V, Total R = 2 + 2 + 1 = 5 Ω

I = V / R = 3 / 5 = 0.6 A

Parallel: e.m.f = 1.5 V, Total internal R = 2 || 2 = 1 Ω, Total R = 1 + 1 = 2 Ω

I = 1.5 / 2 = 0.75 A

Answer: Series: 0.6 A; Parallel: 0.75 A

(b) If the 1 Ω resistor is substituted by an 11 Ω resistor, calculate the new current in both cases.

Series: Total R = 2 + 2 + 11 = 15 Ω

I = 3 / 15 = 0.2 A

Parallel: Total R = 1 + 11 = 12 Ω

I = 1.5 / 12 = 0.125 A

Answer: Series: 0.2 A; Parallel: 0.125 A

(c) Advise a better connection for 1 Ω and 11 Ω resistors.

For 1 Ω, parallel gives higher current (0.75 A vs. 0.6 A). For 11 Ω, series gives higher current (0.2 A vs. 0.125 A).

Answer: Parallel for 1 Ω; Series for 11 Ω

SECTION C (15 Marks)

Answer all questions from this section.

10. A farmer threw an arrow of mass 15 g at a speed of 50 m/s after a monkey which was in a farm of maize. Unfortunately, the arrow penetrated a depth of 5 cm in a soft body of the tree. Calculate the power on the arrow.

Power = Work / Time. Work = Force × Distance.

Assume constant deceleration in tree:

Initial velocity u = 50 m/s, final velocity v = 0, distance s = 0.05 m.

$v^2 = u^2 + 2as$, $0 = 50^2 + 2a \times 0.05$

$a = -2500 / 0.1 = -25000$ m/s²

Force F = ma = 0.015 kg × 25000 = 375 N

Work = F × s = 375 × 0.05 = 18.75 J

Time t = 2s / (u + v) = 2 × 0.05 / (50 + 0) = 0.002 s

Power = 18.75 / 0.002 = 9375 W

Answer: Power = 9375 W