THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL OF TANZANIA

FORM TWO NATIONAL ASSESSMENT

032 **ENGINEERING SCIENCE**

Time: 2:30 Hours. **ANSWER** **Year: 2024**

Instructions

1. This paper consists of sections **A**, **B** and **C** with a total of **ten (10)** questions.
2. Answer **all** questions.
3. Section A carries **15** marks; section B carries **70** marks and section C carries **15** marks.
4. All writing must be in **black** or **blue** ink and drawings must be in **pencil**.
5. Cellular phones and unauthorized materials are **not allowed** in the examination room.
6. Write your **Assessment Number** at the top-right hand corner of every page.

FOR EXAMINER'S USE ONLY		
QUESTION NUMBER	SCORE	EXAMINER'S INITIIALS
1		
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TOTAL		
CHECKER'S INITIALS		

SECTION A (15 Marks)

Answer **all** questions in this section.

(i) A car burns large amount of fuel to provide energy when climbing up a hill at an increased speed. What kind of energy does the car transform.

A Heat energy to Mechanical energy.

B Chemical energy to Heat energy.

C Chemical energy to Mechanical energy.

D Heat energy to Chemical energy.

Answer: C. Chemical energy to Mechanical energy.

Reason: The car converts chemical energy stored in the fuel into mechanical energy that moves the car upward against gravity.

(ii) What are the applications of plane mirrors.

A Plane mirrors are used in hair salons.

B Plane mirrors are used as domestic shaving mirrors.

C Plane mirrors are used as cars side mirrors.

D Plane mirrors are used in periscopes.

Answer: D. Plane mirrors are used in periscopes.

Reason: Plane mirrors are used in periscopes to reflect light at equal angles, allowing observation over obstacles or around corners.

(iii) A domestic vacuum flask thermos prevents loss of heat due to conduction convection and radiation. How does the inner glass vessel with a vacuum between wall prevent heat loss.

A By conduction and radiation.

B By radiation and convection.

C By convection only.

D By convection and conduction.

Answer: D. By convection and conduction.

Reason: The vacuum between the walls prevents both convection and conduction since there are no particles to transfer heat.

(iv) A rod of an insulating material with positive charge was rubbed with a piece of fabric. The fabric was then tested for electric charge. Which result would you expect on piece of fabric.

A A positive charge equal to that on the rod.

B A negative charge equal to that on the rod.

C A positive charge less than that on the rod.

D A negative charge greater than that on the rod.

Answer: B. A negative charge equal to that on the rod.

Reason: When the rod becomes positively charged, it loses electrons to the fabric, making the fabric gain equal negative charge.

(v) Four students were discussing the measurements of relative density of a substance. Each student stated the meaning of the relative density as follows.

1 Relative density is the ratio of the mass of a substance to the mass of an equal volume of water.

2 Relative density is the ratio of the weight of a substance with certain volume to the weight of water with the same volume as that of substance.

3 Relative density is the ratio of the density of a substance to the density of an equal volume of water.

4 Relative density is the ratio of the volume of a substance to the mass of an equal volume of water.

Who were correct among these students.

A 1, 2 and 4.

B 1, 3 and 4.

C 1, 2 and 3.

D 2, 3 and 4.

Answer: C. 1, 2 and 3.

Reason: Relative density can be expressed in terms of mass, weight, or density ratio compared to an equal volume of water, but not volume-to-mass ratio.

(vi) The figure below is a velocity-time graph which represents the motion of a car travelling on a straight road from point A to point D via point B and C. How would you describe the acceleration of a car.

A Acceleration is positive from A to B zero from B to C and negative from C to D.

B Acceleration is negative from A to B zero from B to C and negative from C to D.

C Acceleration is zero from A to B positive from B to C and negative from C to D.
D Acceleration is zero from A to B negative from B to C and positive from C to D.

Answer: A. Acceleration is positive from A to B, zero from B to C and negative from C to D.
Reason: Positive acceleration means increasing velocity, constant velocity means zero acceleration, and decreasing velocity means negative acceleration.

(vii) Why is velocity of the sound in air different in summer and in winter period.
A Because density of air is higher in summer period.
B Because pitch of sound halves in summer period.
C Because density of air is lower in summer period.
D Because pitch of air doubles in winter period.

Answer: C. Because density of air is lower in summer period.
Reason: Warm air is less dense than cold air, so sound travels faster in summer because molecules move more freely.

(viii) Teacher asked the Form Two Students why do we apply suitable lubricant to the surfaces of machine parts which slides over each other. Students' responses were as follows.
i To reduce friction between the moving surface.
ii To reduce the wear on the surfaces.
iii To carry away any heat which is generated at the surfaces.
iv To protect the metal surfaces against rust and corrosion.
Which of the stated reasons were correct.
A i ii and iii.
B i iii and iv.
C i ii and iv.
D ii iii and iv.

Answer: A. i, ii and iii.
Reason: Lubricants reduce friction and wear and help remove heat produced during motion, while corrosion protection is secondary.

(ix) You were given a seesaw with several forces. Thereafter you discovered that the sum of the moments acting on a seesaw was equal to zero but the sum of upward and downward forces was not equal to zero. What can you conclude.

A The seesaw was rotated to clockwise or anticlockwise.

B The seesaw was moved vertically upward or downward.

C The seesaw was remained stationary or moved horizontally.

D The seesaw was tilted to angle 300 or 450.

Answer: B. The seesaw was moved vertically upward or downward.

Reason: When the sum of moments is zero but forces are unbalanced, the system translates vertically without rotation.

(x) A man has to roll an empty drum steadily along an inclined plane from the ground to position B which is h metres above the ground as shown in the figure. In the first attempt a maximum effort F failed to roll the drum steadily to position B. What modification would you recommend so that the drum could be rolled steadily to position B with maximum effort F?

A Reduce the length of the inclined plane L.

B Reduce the size of angle θ.

C Increase the length of the inclined plane L.

D Increase the size of angle α.

Answer: C. Increase the length of the inclined plane L.

Reason: Increasing the length of the plane reduces its slope, thereby reducing the required effort for the same height.

2. Match the functions of measuring instruments in List A with their corresponding instruments in List B by writing a letter of the correct response.

List A	**List B**
(i) The measure of its tendency to cause a body to rotate about specific point or axis. (ii) The forces for turning a steering wheel applied by hands at opposite sides with equal forces but opposite in direction. (iii) It continues in its existing state of rest or uniform motion in a straight line, unless is changed by an external force. (iv) It is a measure of the force that can cause an object to rotate about an axis. (v) It is equal to the change of momentum of an object, when mass is constant.	A. Couple B. Equilibrium C. Impulse D. Inertia E. Moment of a force F. Neutral equilibrium G. Stable equilibrium H. torque

Answers

(i)	(ii)	(iii)	(iv)	(v)
E	A	D	H	C

3. (a) Briefly describe the components of an atom. Give three elements.

(i) **Protons** – Positively charged particles located in the nucleus of an atom. They determine the atomic number of the element.

(ii) **Neutrons** – Neutral particles also located in the nucleus. They add to the mass of the atom but do not affect the charge.

(iii) **Electrons** – Negatively charged particles moving in orbits (electron shells) around the nucleus.

(b) By using sketches, comment on the behaviour of the leaf of the electroscope when:

(i) **The object has negative charge**

When a negatively charged object is brought near the top of an electroscope, electrons are repelled

down to the leaf. Both leaves acquire like charges, repel each other, and diverge. The more negative the object, the larger the divergence of the leaves.

(ii) **The object has positive charge**

When a positively charged object is brought near the electroscope, electrons are attracted toward the top terminal. This leaves the leaves positively charged, causing them to repel each other and diverge. The divergence increases with the strength of the positive charge.

4. A certain mass of gas is contained in a cylinder by a piston. The temperature of the gas is 15°C, pressure is 1.3 bar, and its volume is 1.6 litres. The gas is allowed to expand to a volume 5.6 litres at a constant temperature and then the temperature is raised to 70°C at a constant pressure. What is the final pressure and volume of the gas.

Step 1: Expansion at constant temperature (Boyle's Law)

$P_1V_1 = P_2V_2$

$P_2 = (P_1V_1)/V_2 = (1.3 \times 1.6) / 5.6 \approx 0.371$ bar

Step 2: Heating at constant pressure (Charles' Law)

$V_2 / T_2 = V_3 / T_3$

$T_2 = 15 + 273 = 288$ K, $T_3 = 70 + 273 = 343$ K

$V_3 = V_2 \times (T_3 / T_2) = 5.6 \times (343 / 288) \approx 6.67$ litres

Final pressure after expansion = 0.371 bar, Final volume after heating = 6.67 litres.

5. A driver uses a screw jack to support the axle of his lorry of load 5.6 kN. The screw jack has an effort arm of effective radius of 318 mm and a single-start square thread of 5 mm lead. Determine the efficiency of the jack if an effort of 70 N is required to raise the car's axle.

Given: Load W = 5.6 kN = 5600 N, Effort E = 70 N, radius r = 0.318 m, lead l = 0.005 m.

Step 1: Mechanical advantage (MA)

MA = Load / Effort = 5600 / 70 = 80

Step 2: Velocity ratio (VR)

VR = (2π × radius of handle) / lead = (2 × 3.142 × 0.318) / 0.005 ≈ 399.5

Step 3: Efficiency

$\eta = (MA / VR) \times 100\% = (80 / 399.5) \times 100 \approx 20.03\%$

Efficiency of the jack ≈ 20%.

6. A uniform bridge 32 m long weighs 50×10^3 kg and a lorry weighing 15×10^3 kg is positioned 8 m from one end of the bridge. Considering that the weight of the bridge will act at its centre of gravity halfway along it, draw the force diagram and find the force exerted on each end support of the bridge.

Step 1: Forces

Weight of bridge $Wb = 50 \times 10^3 \times 9.81 \approx 490{,}500$ N

Weight of lorry $Wl = 15 \times 10^3 \times 9.81 \approx 147{,}150$ N

Step 2: Moments about one support (assume left support A)

Distance of bridge CG from A = 32 / 2 = 16 m

Distance of lorry from A = 8 m

$RA \times 0 + RB \times 32 = (490{,}500 \times 16) + (147{,}150 \times 8)$

Sum of forces: $RA + RB = 490{,}500 + 147{,}150 = 637{,}650$ N

Step 3: Solve for forces

Taking moments about A:

$RB \times 32 = (490{,}500 \times 16) + (147{,}150 \times 8) = 7{,}848{,}000 + 1{,}177{,}200 = 9{,}025{,}200$

$RB = 9{,}025{,}200 / 32 \approx 282{,}037.5$ N

$RA = 637{,}650 - 282{,}037.5 \approx 355{,}612.5$ N

Force on left support RA ≈ 356 kN, Force on right support RB ≈ 282 kN.

7. A force of 50 N is applied to the box containing books to make it slide over a horizontal floor. If the coefficient of friction between the box and the floor is 0.5, find the mass of the box.

Friction force $F = \mu \times N$, where $N = mg$

$50 = 0.5 \times m \times 9.81$

$m = 50 / (0.5 \times 9.81) \approx 10.2$ kg

Mass of the box ≈ 10.2 kg.

8. A man accelerated a 10 tons' vehicle from initial velocity to a velocity of 20 m/s in 3 seconds and he found that the kinetic energy was changed to 355 kJ. Calculate:

Given: m = 10 tons = 10,000 kg, ΔKE = 355 kJ = 355,000 J, v = 20 m/s, t = 3 s

(a) Initial velocity u using $\Delta KE = 0.5\ m\ (v^2 - u^2)$

$355{,}000 = 0.5 \times 10{,}000 \times (20^2 - u^2)$

$355{,}000 = 5{,}000 \times (400 - u^2)$

$(400 - u^2) = 355{,}000 / 5{,}000 = 71$

$u^2 = 400 - 71 = 329$

$u \approx \sqrt{329} \approx 18.14$ m/s

(b) Acceleration a using $v = u + at$

$20 = 18.14 + a \times 3$

$a = (20 - 18.14)/3 \approx 0.62$ m/s²

Initial velocity ≈ 18.14 m/s, Acceleration ≈ 0.62 m/s².

9. A car was driven through corrugated road at a speed of 12 m/s for 6 seconds and then it was accelerated for 4 seconds to a speed of 25 m/s. This speed was maintained for 4 seconds until the brake was applied for 2 seconds to stop the car. By the aid of velocity-time graph, estimate the total distance covered on this journey.

Step 1: Distance at constant speed 12 m/s for 6 s

$d_1 = v \times t = 12 \times 6 = 72$ m

Step 2: Distance during acceleration from 12 to 25 m/s in 4 s

Average speed = (12 + 25)/2 = 18.5 m/s

$d_2 = 18.5 \times 4 = 74$ m

Step 3: Distance at constant speed 25 m/s for 4 s

$d_3 = 25 \times 4 = 100$ m

Step 4: Distance during deceleration to 0 in 2 s

Average speed = (25 + 0)/2 = 12.5 m/s

$d_4 = 12.5 \times 2 = 25$ m

Total distance = 72 + 74 + 100 + 25 = 271 m

10. (a) When a motor car tyre was tested in a garage at a temperature of 17°C was found to have a pressure of 290 $\times 10^3$ Pa. Assume that the volume of the air inside the tyre remains constant, what would be the value of the pressure after the tyre has been exposed in the sun so that its temperature rises to 27°C?

Use Gay-Lussac's Law:

$P_1/T_1 = P_2/T_2$, T in Kelvin

$T_1 = 17 + 273 = 290$ K, $T_2 = 27 + 273 = 300$ K

$P_2 = P_1 \times (T_2 / T_1) = 290{,}000 \times (300 / 290) \approx 300{,}000$ Pa

Pressure after heating ≈ 300 kPa.

(b) At a temperature of 27°C, a volume of air in a motorcycle tyre at a gauge pressure of 750 mmHg is 3000 cm^3. Estimate the volume of the air inside the tyre of the motorcycle at the Standard Temperature and Pressure (S.T.P).

Step 1: Convert temperature to Kelvin

$T_1 = 27 + 273 = 300$ K, $T_2 = 273$ K (STP)

Step 2: Convert pressure to absolute

$P_1 = 750$ mmHg + 760 mmHg (atm) ??? Actually gauge to absolute: Pabs = Pgage + Patm = 750 + 760 = 1510 mmHg

Step 3: Use Boyle's and Charles' combined law

$P_1V_1/T_1 = P_2V_2/T_2$

$V_2 = P_1V_1T_2 / (P_2T_1) = (1510 \times 3000 \times 273) / (760 \times 300) \approx 5145$ cm^3

Volume at STP ≈ 5145 cm^3.