THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION, 1994

035 **ENGINEERING SCIENCE**

Time: 3 Hours **ANSWERS**

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1. This paper consists of Parts: I and II. Part II consists of Sections; A, B and C.
2. Attempt ALL 20 questions in Part I and any FIVE in part II. You must attempt at least ONE question from section A, B and C.
3. Part I carries 40%

   Part II carries 60%

   Take g = 9.81 m/s^2 and pie = 3.14

4. Write your **Examination Number** on every page of your answer booklet(s).

1. Define pressure. Give its SI units.
Pressure is the force acting per unit area.
SI unit: Pascal (Pa)
1 Pa = 1 N/m^2

2. Give a name of an instrument used to measure
(a) Length – Ruler
(b) Time – Stopwatch or clock
(c) Temperature – Thermometer
(d) Mass – Beam balance

3. The frictional force acting on a body of mass 100 kg is 196 N. Calculate the coefficient of friction.
Friction force = μ x Normal force
Normal force = mass x g = 100 x 9.8 = 980 N
196 = μ x 980
μ = 196 / 980 = 0.2

4. Distinguish between sensible heat and latent heat.
Sensible heat causes a change in temperature.
Latent heat causes a change in state without a change in temperature.

5. Distinguish between the coefficient of superficial expansion and coefficient of cubical expansion.
Coefficient of superficial expansion relates to area change due to temperature rise.
Coefficient of cubical expansion relates to volume change due to temperature rise.

6. State Archimedes' principle.
Archimedes' principle states that a body immersed in a fluid experiences an upthrust equal to the weight of the fluid displaced.

7. Calculate the torque produced when a force of 50 N acts on a body 2.0 m perpendicular from a pivot.
Torque = Force x Distance = 50 x 2.0 = 100 Nm

8. Give any two reasons which make mercury a better liquid to be used in a thermometer than water.

- Mercury has a uniform rate of expansion.
- Mercury does not stick to glass.

9. A hammer is used to drive a nail. If its momentum changes by 10 kgm/s in 0.1 sec, calculate the driving force.
Force = Change in momentum / Time = 10 / 0.1 = 100 N

10. Define work. Give its SI units.
Work is done when a force causes displacement in the direction of the force.
SI unit: Joule (J)

11. (a) Name two modes of heat transfer.

- Conduction
- Convection

(b) What is the necessary condition for heat to flow?
There must be a temperature difference between the two bodies.

12. Define Simple Harmonic Motion.
Simple Harmonic Motion is a type of oscillatory motion where the restoring force is directly proportional to displacement and directed towards the mean position.

13. Give two examples of Simple Harmonic Motion.

- Oscillation of a pendulum
- Vibration of a mass on a spring

14. Calculate the effective value of 15 ohms and 10 ohms resistor connected in:
(a) Series: $R = R1 + R2 = 15 + 10 = 25$ ohms
(b) Parallel: $1/R = 1/15 + 1/10 = (2 + 3) / 30 = 5/30 = 1/6$
$R = 6$ ohms

15. The resistance of an aluminium wire 750 cm long and 2 mm diameter is 20 ohms. Find the resistivity of the aluminium.
Length $L = 750$ cm $= 7.5$ m
Radius $r = 1$ mm $= 0.001$ m, $A = \pi r^2 = 3.14 \times (0.001)^2 = 3.14 \times 10^{-6}$ m²
$R = \rho L/A \rightarrow \rho = RA/L = 20 \times 3.14 \times 10^{-6} / 7.5 \approx 8.37 \times 10^{-6}$ Ωm

16. (a) What is capacitance?
Capacitance is the ability of a system to store electric charge per unit voltage.
SI unit: Farad (F)

(b) Calculate the combined capacitance of 2 μF and 3 μF capacitors in:
(i) Series: $1/C = 1/2 + 1/3 = (3 + 2)/6 = 5/6 \rightarrow C = 6/5 = 1.2$ μF
(ii) Parallel: $C = 2 + 3 = 5$ μF

17. (a) State the fundamental law of magnetism.
Like poles repel, unlike poles attract.

(b) Name any two methods of making magnets.

- Stroking method
- Electrical method (using current through a coil)

18. What are the units of measurement of the following quantities?
(a) Magnetic flux – Weber (Wb)
(b) Magnetic flux density – Tesla (T)
(c) Charge – Coulomb (C)
(d) Capacitance – Farad (F)

19. How much heat is developed in a resistor with a p.d. of 12 volts across its ends and a current of 20 A flowing for 5 minutes?
H = V x I x t = 12 x 20 x (5 x 60) = 12 x 20 x 300 = 72,000 J

20. Write the meanings of the following:
(a) Electron – A negatively charged subatomic particle.
(b) Ion – An atom or molecule with a net electric charge due to loss or gain of electrons.
(c) Voltmeter – A device used to measure voltage.
(d) Ammeter – A device used to measure electric current.

21. Distinguish a scalar from a vector quantity. A car runs at a constant speed of 15 m/s for 300 seconds and then accelerates uniformly to a speed of 25 m/s over a period of 20 seconds. This speed is maintained for 300 seconds before the car is brought to rest with uniform deceleration in 30 seconds. Determine:
(a) the acceleration while the velocity changes from 15 m/s to 25 m/s
(b) the total distance travelled
(c) the average speed of the car

Scalar quantities have only magnitude (e.g., speed, mass)
Vector quantities have both magnitude and direction (e.g., velocity, force)

(a) Initial velocity u = 15 m/s
Final velocity v = 25 m/s
Time t = 20 s
$a = (v - u)/t = (25 - 15)/20 = 10/20 = 0.5\ m/s^2$

(b) 1st part: Distance = speed x time = 15 x 300 = 4500 m
2nd part: u = 15, v = 25, t = 20 → s = (u + v)/2 x t = (15 + 25)/2 x 20 = 400 m
3rd part: Distance = speed x time = 25 x 300 = 7500 m
4th part: u = 25, v = 0, t = 30 → s = (u + v)/2 x t = (25 + 0)/2 x 30 = 375 m
Total distance = 4500 + 400 + 7500 + 375 = 12,775 m

(c) Total time = 300 + 20 + 300 + 30 = 650 s
Average speed = total distance / total time = 12775 / 650 ≈ 19.65 m/s

22. What is the centre of gravity of a body?
The centre of gravity is the point at which the entire weight of a body appears to act, regardless of its orientation.

23. (a) Draw a simple labelled diagram of a hydraulic press.

(b) A hydraulic press has pistons of cross-sectional areas 100 cm^2 and 50,000 cm^2 respectively. The machine is 80% efficient and a force of 10 N is applied. What is the load overcome?
A1 = 100 cm^2, A2 = 50000 cm^2
F1 = 10 N, Efficiency = 80% = 0.8
F2 = (A2 / A1) x F1 x efficiency = (50000 / 100) x 10 x 0.8 = 500 x 10 x 0.8 = 4000 N

24. A 1 kg block of copper has its temperature raised by 20 degrees centigrade in 1.9 minutes using an electric immersion heater.
(a) At what rate is heat energy being supplied to the block?
$Q = mc\Delta T = 1 \times 380 \times 20 = 7600$ J
Time = 1.9 min = 114 s
Rate = Q / t = 7600 / 114 ≈ 66.67 W

(b) If the heater takes 2 A from a 10 V supply, what is the efficiency of the heater?
Input power = VI = 10 x 2 = 20 W
Efficiency = output / input = 66.67 / 20 = 3.33 → This is over 100%, so input may be energy instead.
Energy input in 114 s = 20 x 114 = 2280 J
Efficiency = 7600 / 2280 = 3.33 → again over 100%, implies possible confusion in question or data.

25. State Boyle's law as applied to expansion of gases.
Boyle's Law: For a fixed mass of gas at constant temperature, pressure is inversely proportional to volume.
Given:
$P1 = 3 \times 10^5$ N/m^2, $V1 = 10^{-3}$ m^3
$V2 = 1.5 \times 10^{-3}$ m^3
P2 = ?
P1V1 = P2V2 → P2 = P1V1 / V2
$P2 = (3 \times 10^5 \times 10^{-3}) / 1.5 \times 10^{-3} = 300 / 1.5 = 2 \times 10^5$ N/m^2

26. (a) State the laws of refraction.
- The incident ray, refracted ray, and normal lie in the same plane.
- The ratio of sine of angle of incidence to sine of angle of refraction is constant (Snell's law).

(b) (i) sin i / sin r = n → sin 38° / sin r = 1.33 → sin r = sin 38° / 1.33 = 0.6157 / 1.33 ≈ 0.463
r ≈ 27.6°

(ii) Speed in water = speed in air / refractive index = 3×10^8 / 1.33 ≈ 2.26×10^8 m/s

27. (a) A milliammeter gives full-scale deflection at 0.002 A and has resistance 40 ohms. What resistance is needed to convert it into an ammeter reading up to 20 A?
Shunt resistance Rs = (Ig x Rg) / (I - Ig) = (0.002 x 40) / (20 - 0.002) ≈ 0.08 / 19.998 ≈ 0.004 Ω
It must be connected in parallel.

(b) Explain briefly the principle under which a moving coil meter works.
A moving coil meter works on the principle that a current-carrying coil placed in a magnetic field experiences a torque proportional to the current.

28. (a) State Faraday's law of magnetic induction.
The induced emf in a circuit is directly proportional to the rate of change of magnetic flux through the circuit.

(b) A 0.2 m wire carries 10 A from East to West in a magnetic field of 0.1 Wb/m² directed downwards.
$F = BIL = 0.1 \times 10 \times 0.2 = 0.2$ N
Direction: Use right-hand rule – force acts towards South.

29. (a) Define the term "electrochemical equivalent" as applied to electrolysis.
The electrochemical equivalent is the mass of a substance deposited or liberated per unit charge.

(b) $m = ZIt \rightarrow I = m / (Zt)$
$m = 0.459$ g $= 0.000459$ kg
$Z = 3.3 \times 10^{-7}$ kg/C
$t = 30$ min $= 1800$ s
$I = 0.000459 / (3.3 \times 10^{-7} \times 1800) \approx 0.000459 / 5.94 \times 10^{-4} \approx 0.772$ A