higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ENGINEERING PHYSICS N6

30 JULY 2019

This marking guideline consists of 8 pages.

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QUESTION 1: SOUND

1.1

The pitch of a sound depends on its frequency.✓ A high note is produced by a high frequency and a low note by a low frequency.✓

OR

High frequency = High note✓ Low frequency = Low note✓ (2)

1.2 A characteristic of every standing wave pattern is that there are points along the medium that appear to be standing still. These points, sometimes described as points of no displacement, are referred to as nodes.✓

There are other points along the medium that undergo vibrations between a large positive and large negative displacement. These are the points that undergo the maximum displacement during each vibrational cycle of the standing wave. In a sense, these points are the opposite of nodes, and so they are called antinodes.✓ (2)

1.3 A displacement node is a point on a standing wave✓ where the displacement of the particle is zero at all times.✓ A displacement antinode is a point on a standing wave where the amplitude of vibration is the greatest.✓ (3)

1.4 $\ell_1 + C = \frac{V}{4f}$ $\ell_1 + C = \frac{3V}{4f}$

$14,7 + C = \frac{V}{4 \times 480}$ …… (1) $48,7 + C = \frac{3V}{4 \times 480}$ ……. (2)

$(4 \times 480)(14,7 + C) = V$ ✓ $(4 \times 480)(48,7 + C) = V \times 3$✓

$V_{left} = V_{right}$
$1\,920\,(14,7 + C) = 640\,(48,7 + C)$
$28\,224 + 1\,920\,C = 30\,976 + 640\,C$
$1\,920\,C - 640\,C = 30\,976 - 28\,224$
$1\,280\,C = 2\,752$
$C = 2,15$ ✓

Assume C = 2,15 in equation 1

$V = (4 \times 480)(14,7 + 2,15)$ ✓
$= 1\,920 \times 16,85$
$= 32\,352$ cm/s
$= 323,52$ m/s ✓

For resonance in an open pipe for = $\frac{V}{2(l + C)}$

$= \frac{323,52}{2(0,61 + 0,0215)}$ ✓

$= \frac{323,52}{1,263}$

= 256,15 Hz✓ (7)

1.5 f = f but Vo = Vs

$f = f\frac{(V \pm Vo)}{(V \pm Vo)}$

$51\,000 = 49\,000\frac{(325 + Vo)}{(325 - Vo)}$ ✓

$1,0408 = \frac{(325 + Vo)}{(325 - Vo)}$

1,0408(325 - Vo) = 325 + Vo

338,265 – 1,0408 Vo = 325 + Vo✓

338,265 – 325 = 1,0408 Vo + Vo

13,265 = 2,0408 Vo

$Vo = \frac{13,625}{2,0408}$ ✓

Vo = 6,5 m/s✓ (4)

1.6 1.6.1 36 km/h = 36 ÷3,6 = 10 m/s

$f = f\frac{(V \pm Vo)}{(V \pm Vo)}$

$f = \frac{1200 \times (325 + 0)}{(325 - 10)}$ ✓

f = 1238,085 Hz✓ (3)

1.6.2 $f = f\frac{(V \pm Vo)}{(V \pm Vo)}$ ✓

$f = \frac{1200 \times (325 + 0)}{(325 + 10)}$ ✓

f = 1164,179 Hz✓ (2)

1.6.3 $f = f\frac{(V \pm Vo)}{(V \pm Vo)}$

$f = \frac{1200 \times (325 + 5)}{(325 + 10)}$ ✓

f = 1182,089 Hz✓ (2)

[25]

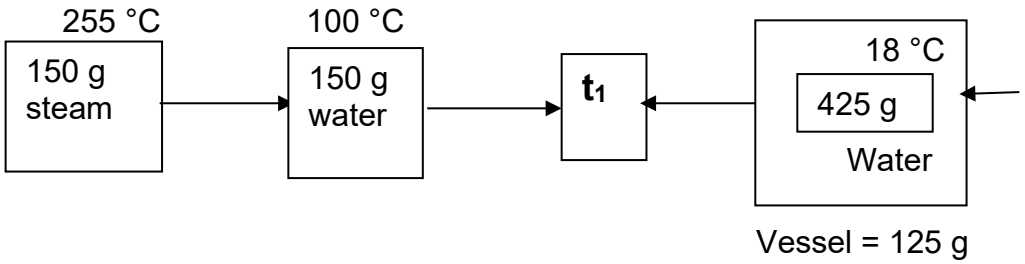
QUESTION 2: THERMODYNAMICS

2.1 During an Isothermic process the temperature remains constant during compression. (Boyle's law) $P_1V_1 = P_2V_2$.✓ In practice it can be obtained by compressing the gas very slowly so that it has time to give off the generated heat to its environment.✓ (2)

2.2 False (1)

2.3 The units of specific heat capacity are J/kg.K or KJ/kg.°C. Specific heat capacity (shc) of a substance is the amount of heat required✓ to raise the temperature of 1 kg of the substance by 1 °C (or by 1 K).✓ (2)

2.4



Heat lost through steam

$$m \times shc \times st + m \times shc \times st + m \times shc \times \Delta t$$
$$150\ g \times 0,45 \times 50°C + 150\ g \times 538,7 + 150\ g \times 1 \times (100 - t_1)✓$$
$$3375 + 80805 + 15\ 000 - 150\ t_1$$
$$99\ 180 - 150\ t_1 ✓$$

Heat gained Water

$$M \times c \times \Delta t + M \times c \times \Delta t$$
$$425\ g \times 1 \times (t_1 - 18\ °C) + 125 \times 0,2 \times (t_1 - 18)✓$$
$$425\ t_1 - 7\ 650 + 25\ t_1 - 450$$
$$450\ t_1 - 8\ 100✓$$

Heat lost = Heat gained
$$99\ 180 - 150\ t_1 = 450\ t_1 - 8\ 100✓$$
$$107\ 280 = 600\ t_1$$
$$t_1 = 178,8\ °C✓$$ (6)

2.5 2.5.1 Gas constant (γ) = $\frac{Cp}{Cv} = \frac{1,066}{0,785}$ = 1,36✓✓ (2)

2.5.2 $P_1 \times V_1^n = P_2 \times V_2^n$

$V_2 = \left(\frac{680}{148}\right)^{1,36} \times 1,8 \times 10^{-3}$✓

$V_2 = 0,0144\ m^3$✓ (2)

2.5.3 Work done = $\frac{P_1 \times V_1 - P_2 \times V_2}{\alpha - 1}$

Work done = $\frac{680 \times 10^3 \times 0,018 - 148 \times 10^3 \times 0,0144}{1,36 - 1}$ ✓

Work done = $\frac{12240 - 2131,2}{0,36}$

Work done = 28,08 kJ✓ (2)

2.5.4 Q = ΔU + Wd therefor adiabatic 0 = ΔU + W

ΔU = - Wd = -28,08 kJ (1)

2.6 2.6.1 $\eta = \frac{t_1 - t_2}{t_1} \times 100$ t_1 =293 +273 = 566 K t_2 = 52 + 273 = 325 K

$\eta = \frac{566 - 325}{566} \times 100$✓

η = 42,579 %✓ (2)

2.6.2 Work done = $m \times R \ln \frac{V_2}{V_1} (t_2 - t_1)$

Work done = 0,23 × 280 ln 2,5 × (566 – 325)✓

Work done per 10 strokes = 142,22 kJ✓ (2)

2.7 Heat lost by steam at 110 °C + Heat lost by water at 110 °C = Heat gained by water

(1 kg × shc) + 4187 × 1 × 40 = 19 × 4187 × 40 ✓

1 × shc + 167 480 = 3 182 120 ✓

Shc = 3 014 640 J/kg.K or 3 MJ/kg.K ✓ (3)

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QUESTION 3: ELECTROSTATICS

3.1 The ratio of the capacitance✓ with and without the dielectric between the plates is called the dielectric constant or relative permittivity.✓ (2)

3.2 A coulomb is the quantity of electric charge which moves through a conductor in one second✓ when a constant current of one ampere flows through the conductor.✓ (2)

3.3 The influence of a charged object and orientation✓ of the charges on the uncharged object✓ is called electrostatic induction. (2)

3.4 3.4.1 $C = Q \div C$

Thus capacitance = charge in coulomb ÷ potential difference

$$\text{Charge} = 55 \times 10^{-6} \times 240 \text{ V}$$
$$= 0{,}0132 \text{ C} \checkmark$$

When the capacitors are connected in parallel, the total capacitance is 90 µF and the charge of 0,0132 C is divided between the two capacitors.

$0{,}0132 \text{ C} = 90 \times 10^{-6} \times V \checkmark$
$V = 146{,}667 \text{ Volts} \checkmark$ (3)

3.4.2 Electrostatic energy = $\frac{1}{2}C V^2$
$= \frac{1}{2} \times 55 \times 10^{-6} \times (240)^2$
$= 1{,}584 \text{ J} \checkmark$

Electrostatic energy = $\frac{1}{2}C V^2$
$= \frac{1}{2} \times 55 \times 10^{-6} \times (146{,}667)^2 \checkmark$
$= 0.592\text{J} \checkmark$ (3)

3.5 $C = \frac{Eo \times Er\,(n - 1).a}{d}$

$C = \frac{8{,}85 \times 10^{-12} \times 7(5 - 1) \times 0{,}045}{0{,}0004} \checkmark \checkmark$
$C = 2{,}788 \times 10^{-8}$ farad ✓
$C = 0{,}02788 \times 10^{-6}$ farad
$C = 0{,}02788$ µC ✓ (4)

3.6 $F_{up} = F_{down}$

$Q = \frac{mg}{E}$
$Q = \frac{2{,}4 \times 10^{-15} \times 9{,}8}{5 \times 10^4} \checkmark$
$Q = 4{,}704 \times 10^{-19}$ C ✓

Number of excess electrons = $\frac{4{,}704 \times 10^{-19}}{1{,}6 \times 10^{-19}}$
$= 2{,}94\ e^-$ use $3\ e^- \checkmark$ (3)

3.7 3.7.1 electrical charge
3.7.2 one second
3.7.3 current
3.7.4 ratio
3.7.5 dielectric
3.7.6 relative permittivity

(6 × 1) (6)
[25]

QUESTION 4

4.1 4.1.1 length
4.1.2 B-particles
4.1.3 4
4.1.4 X-rays
4.1.5 gamma

(5 × 1) (5)

4.2 4.2.1 Thermionic emission (1)

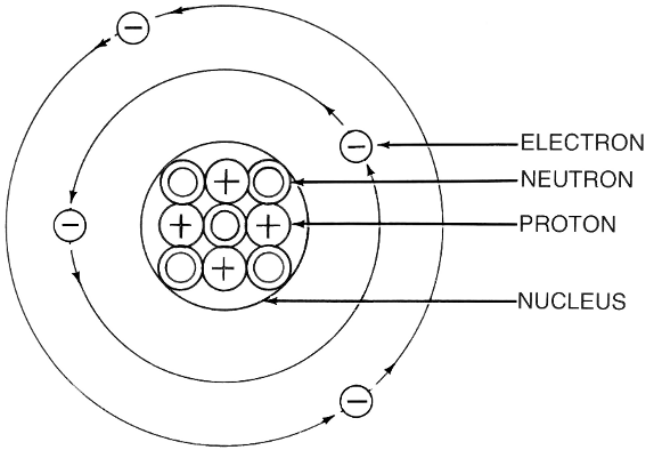
4.2.2 Due to the heating, some of the valence electrons obtain sufficient kinetic energy to overcome the attraction forces✓ of the positive atomic kerns and to leave the surface of the metal.✓ (2)

4.2.3 For each electron leaving the metal, a net to positive charge of + 1,6 × 10^{-19} C is formed on the metal.✓ A coulomb force of attraction originates between the positive metal and the negatively charged electron clouds (space charge) in the vicinity of the surface of the metal.✓ (2)

4.3
- When a light beam is projected on specified metals, electrons are also emitted.✓ This is known as the photo electric effect.✓
- External: The electrons are emitted externally and an external current flows.✓
- Internal: The electrons are emitted by the metal internally so that a non-conductor and current will flow in the metal.✓ (4)

4.4
- At the internal photoelectrical effect there must be distinguished between photoresistance and photoelement.✓ Photoresistance shows a variance resistance when light shines on the metal.✓
- This is made possible by very small primary photo currents which is enlarged✓ when the conductivity of the metal is changed when light shines upon this light-sensitive metals.✓
- On the other hand, at photoelements there is a potential build up on the metal,✓ causing a photocurrent without an external voltage applied. Photographic light meters are photoelements.✓ (6)

4.5



✓✓✓ (3)

4.6 Isotopes are different forms of an element that have the same number of protons but different numbers of neutrons.✓ For example many elements such as carbon, potassium and uranium have multiple naturally occurring isotopes.✓ (2)

[25]

TOTAL: 100

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