NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2021

TECHNICAL SCIENCES: PAPER I

MARKING GUIDELINES

Time: 3 hours 150 marks

These marking guidelines are prepared for use by examiners and sub-examiners, all of whom are required to attend a standardisation meeting to ensure that the guidelines are consistently interpreted and applied in the marking of candidates' scripts.

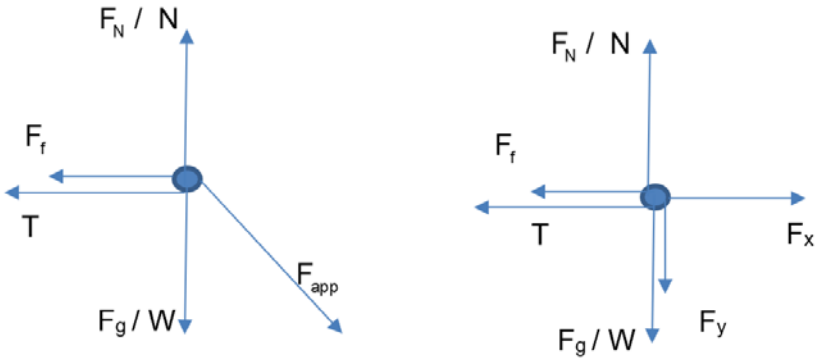
The IEB will not enter into any discussions or correspondence about any marking guidelines. It is acknowledged that there may be different views about some matters of emphasis or detail in the guidelines. It is also recognised that, without the benefit of attendance at a standardisation meeting, there may be different interpretations of the application of the marking guidelines.

QUESTION 1 MULTIPLE-CHOICE QUESTIONS

1.1 D
1.2 B
1.3 C
1.4 C
1.5 B
1.6 C
1.7 D
1.8 D
1.9 B
1.10 C

QUESTION 2

2.1



FORCE	DESCRIPTION	MARKS
F_N /N	Normal force	
F_f	Friction	
F_g /W	Weight	
T	Tension in the rope	
F_{app}	Applied force F_x and F_y components	

2.2 **OPTION 1**

$f_k = \mu_k N$
$= \mu_k(mg + 250 \sin 20°)$
$= 0,15[(15)(9,8) + 250 \sin 20°)\ ]$
$= 34,88$ N

OPTION 2

$f_k = \mu_k N$
$= \mu_k(mg + 250 \cos 70°)$
$= 0,15[((15)(9,8) + 250 \cos 70°)]$
$= 34,88$ N

2.3 **For the 15 kg block**

$F_{net} = ma$
$F_x + (-T) + (-f_k) = ma$
$250 \cos 20^o - T - f_k = 15a$
$250 \cos 20^o - T - 34,88 = 15a$
$-T = 15a - 200,043$ … (1)

For the 30 kg block

$F_{net} = ma$
$T - f_k = 30a$
$T - (0,15 \times 30 \times 9,8) = 30a$
$T = 30a + 44,1$ … (2)

$-T = 15a - 200,043$ …..(1)
$T = 30a + 44,1$ …..(2)
$0 = 45a - 155,943$ …..(1) + (2)
$a = 3,47 \text{ m·s}^{-2}$

2.4 Positive marking from Question 2.3

$T = 30a + 44,1$
$T = 30(3,47) + 44,1$
$T = 148,2 \text{ N}$

2.5 When a net force is applied to an object of mass m, it accelerates the object in the direction of the net force.

OR

When a net force, F_{net}, is applied to an object of mass m, it accelerates in the direction of the net force. The acceleration, a, is directly proportional to the net force and inversely proportional to the mass.

OR

(In terms of momentum)
The net (or resultant) force acting on an object is equal to the rate of change of momentum of the object in the direction of the net force.

2.6 Decrease

Mass increases so acceleration decreases.

QUESTION 3

3.1 The total linear momentum of an isolated system remains constant (is conserved) in magnitude and direction.

3.2 $\frac{504 \times 10^3}{3\,600} = 140 \text{ m} \cdot \text{s}^{-1}$ (if only the answer is given, award two marks)

3.3
$$\Sigma_{p_i} = \Sigma_{p_f} \qquad \text{(to the east/right is +)}$$
$$m_{x+y}v_i = m_x v_f + m_y v_f$$
$$(1\,250 + 3{,}2)(0) = (1\,250)(v_f) + (3{,}2)(140)$$
$$v_f = -0{,}358 \text{ m} \cdot \text{s}^{-1}$$
$$\therefore v_f = 0{,}358 \text{ m} \cdot \text{s}^{-1} \text{ to the west/left}$$

3.4 Impulse is the product of the resultant/net force acting on an object and the time that the resultant/net force acts on the object.

3.5 (to the east/right is +)
$$F_{net} \cdot \Delta t = m_y v_f - m_y v_i$$
$$F_{net} \cdot 1 = (1\,250)(0) - (1\,250)(-0{,}358)$$
$$F_{net} = 447{,}5 \text{ N}$$
$$\therefore F_{net} = 447{,}5 \text{ N}$$

QUESTION 4

4.1 $E_p = mgh$

$E_p = (55)(9,8)(5,4)$

$E_p = 2\,910,6\,J$

4.2 The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant.

4.3 Positive marking from Question 4.1.

Mechanical energy is conserved.

$$(E_P + E_K)_B = (E_P + E_K)_A$$

$$mgh + \frac{1}{2}mv_f^2 = mgh + \frac{1}{2}mv_f^2$$

$$(2\,910,6 + 0) = (55 \cdot 9,8 \cdot 0,2) + \left(\frac{1}{2} \cdot 55 \cdot v_f{}^2\right)$$

$$v_f = 10,095\ m \cdot s^{-1}$$

4.4 $$P = \frac{W}{\Delta t}$$

$$P = \frac{F_{pump} \cdot \Delta X \cdot \cos\theta}{\Delta t}$$

$$P = \frac{(100 \cdot 9,8) \cdot 5,4 \cdot \cos 0°}{(2 \times 60)}$$

$$P = 44,1\ W$$

4.5 **OPTION 1**

Positive marking from Question 4.4

$$\frac{44,1}{(0,135 \cdot 746)} \times \frac{100}{1} = 43,79\%$$

OPTION 2

Positive marking from Question 4.4.

$$\frac{\left(\frac{44,1}{746}\right)}{0,135} \times \frac{100}{1} = 43,79\%$$

QUESTION 5

5.1 Elastic limit is the maximum force that can be applied to a body so that it regains its original form completely on removal of the force.

5.2 $$\sigma = \frac{F}{A}$$

$$\sigma = \frac{596,7 \times 10^{3}}{1,767 \times 10^{-2}}$$

$$\sigma = 33\,769\,100,17 \text{ Pa}$$

$$A = \pi r^{2}$$

$$A = \pi(\frac{0,15}{2})^{2}$$

$$A = 1,767 \times 10^{-2} m^{2}$$

5.3 $$\varepsilon = \frac{\Delta L}{L}$$

$$\varepsilon = \frac{1,08 \times 10^{-3}}{0,2}$$

$$\varepsilon = 0,0054$$

5.4 Strain indicates the ratio of change in dimension to the original dimension.

5.5 Positive marking from Question 5.2 and Question 5.3.

$$K = \frac{\sigma}{\varepsilon}$$

$$K = \frac{33\,769\,100,17}{0,0054}$$

$$K = 6\,253\,537\,069 \text{ Pa}$$

5.6 A perfectly elastic body is a body that regains its original shape and size completely when the deforming force is removed.

Examples: guitar strings, springs, cables, etc.

QUESTION 6

6.1 The property of the fluid to oppose relative motion between the two adjacent layers.

6.2 6.2.1 Temperature

6.2.2 Time

6.3 A **single-grade oil** does not use a polymer additive (Viscosity Index Improver) to change its viscosity.

6.4 To keep the temperature of the oil constant during the experiment.
A change in temperature will influence the viscosity of the oil.

6.5 $X = 80\ °C$

6.6 Change in temperature influences the viscosity of the oil.
Time taken decreases, thus viscosity decreases.
Temperature is inversely proportional to viscosity.
Viscosity decreases thus temperature increases.
Temperature $X = 80\ °C$

QUESTION 7

7.1 Pascal's law states that in a confined liquid at equilibrium, the pressure applied at a point is transmitted equally to the other parts of the liquid.

7.2 Lift A: 4 000 N
Lift B: 2 000 N

7.3 $F_g = m \cdot g$

$F_g = 1\,020,41 \cdot 9,8$

$F_g = 10\,000\ N$

$F_{lifting} = F_g$

From the graph $F_{applied} = 2\ 500\ N$

7.4 The gradient gives the ratio of the lifting force to the applied force.

QUESTION 8

8.1 A capacitor is a device for storing electrical charge.

8.2
$$C = \frac{Q}{V}$$
$$470 \times 10^{-6} = \frac{Q}{6}$$
$$Q = 0,00282\,C$$

8.3 Increase the potential difference in the circuit/add more cells in series.

QUESTION 9

9.1 $\frac{4,5}{3} = 1,5\ V$ (if only the answer is given award one mark)

9.2
$$V = I \cdot R$$
$$2,7 = I \cdot 4,5$$
$$I = 0,6\ A$$

9.3
$$V_T = V_1 + V_2$$
$$4,5 = 2,7 + V_2$$
$$V_2 = 1,8\ V \text{ (if only the answer is given, award two marks)}$$

9.4 Positive marking from Question 9.2 and Question 9.3.

OPTION 1
$$V = I \cdot R_2$$
$$1,8 = 0,6 \cdot R_2$$
$$R_2 = 3\ \Omega$$

OPTION 2
$$V = I \cdot R_T$$
$$4,5 = 0,6 \cdot R_T$$
$$R = 7,5\ \Omega$$
$$R_T = R_1 + R_2$$
$$7,5 = 4,5 + R_2$$
$$R_2 = 3\ \Omega$$

9.5 9.5.1 Decrease

9.5.2 Decrease

QUESTION 10

10.1 Magnet must move quickly in and out of the coil/rate of change of the magnetic flux must increase.

10.2 Faraday's law states that when the magnetic flux linked with the coil changes, an emf is induced in the coil. The magnitude of the induced emf is directly proportional to the rate of change of magnetic flux.

10.3 $$\varepsilon = -\frac{N \cdot \Delta\phi}{\Delta t}$$
$$\varepsilon = -\frac{280 \cdot 1{,}5 \times 10^{-3}}{1}$$
$$\varepsilon = 0{,}42 \text{ V}$$

QUESTION 11

11.1 11.1.1 Radio waves

11.1.2 X-rays

11.2 11.2.1 $c = \lambda \cdot f$

$$3 \times 10^{8} = 620 \times 10^{-9} \cdot f$$

$$f = 4{,}839 \times 10^{14} \text{ Hz}$$

11.2.2 Positive marking from Question 11.2.1.

$$E = h \cdot f$$
$$E = 6{,}63 \times 10^{-34} \cdot 4{,}839 \times 10^{14}$$
$$E = 3{,}208 \times 10^{-19} \text{ J}$$

11.3 Gamma rays have a very high frequency/energy of the photon is high.

QUESTION 12

12.1 Refraction of light.

12.2 Total internal reflection.

12.3 Fibre optics, periscope, endoscope, etc.

12.4 12.4.1 The phenomenon whereby light breaks up into its component colours.

12.4.2 Refraction.

12.4.3 Spectrum.

12.4.4 Violet.

Total: 150 marks