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Physics exemplar examination memo

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Physics exemplar examination paper memorandum

SECTION A

Question 1

1.1 B

1.2 B

1.3 A

1.4 A

1.5 A

1.6 C

1.7 D

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SECTION B

Question 2

2.1.1 In an isolated system, the total linear momentum is conserved in both magnitude and direction. (2)

2.1.2 In the absence of non-conservative forces, the sum of the potential and kinetic energies of an object remains constant. (2)

2.2.1 The velocity of the arrow-block combination after the collision = its velocity at the start of its swing (at the bottom). Since mechanical energy is conserved:

$$(mgh + \frac{1}{2}mv^2)_{bottom} = (mgh + \frac{1}{2}mv^2)_{top}$$

$$0 + \frac{1}{2}(2)v^2_{bottom} = (2)(9,8)(0,2) + 0$$

$$v_{bottom} = 1,98\ m{\cdot}s^{-1}$$ (5)

2.2.2 For the collision of the arrow with the block:

$$m_1v_{i1} + m_2v_{i2} = (m_1 + m_2)v_f$$

$$(0,05)v_{i1} + (1,95)\ 0 = (0,05 + 1,95)(1,98)$$

$$v_{i1} = 79,2\ m{\cdot}s^{-1}$$ (4)

2.3.1 Increases (2)

2.3.2 Stays the same (2)

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Question 3

3.1.1 $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$

$= (20)(4,8) + \frac{1}{2}(-9,8)(4,8)^2 = -16,90$ m

Therefore, the vertical height of the cliff above the water = 16,90 m. (4)

3.1.2 $v_f = v_i + a\Delta t$

$= 20 + (-9,8)(4,8) = -27,04\ m{\cdot}s^{-1}$

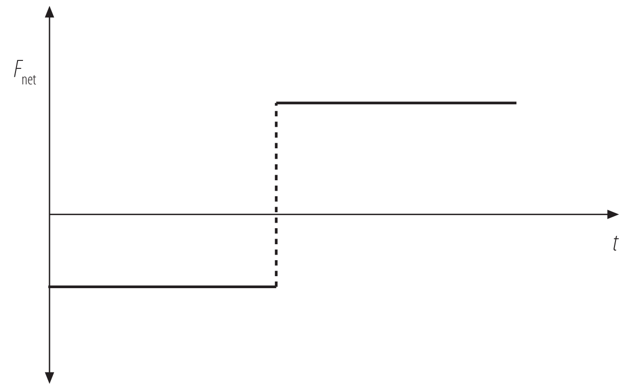
Therefore, the velocity of the ball when it strikes the water is 27,04 $m{\cdot}s^{-1}$ downwards. (4)

3.1.3 $F = mg$

$= (0,1)(-9,8) = -0,98$ N

The force with which the ball strikes the water is 0,98 N downwards. (4)

3.2



(3)

3.3 The force of attraction that two bodies at rest exert on each other is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres. (3)

3.4 As the meteor gets closer to Earth, the distance between the meteor and Earth (r) decreases, while their masses remain constant. Since F is inversely proportional to r^2, F increases. (4)

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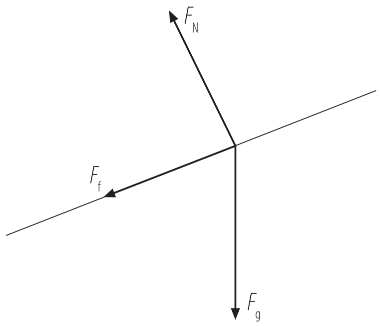
Question 4

4.1 The net work done on an object is equal to the change in the kinetic energy of the object. (2)

4.2.1



(3)

4.2.2 $W_f = W_{nc} = \Delta E_p + \Delta E_k$

$= mgh_f - mgh_i + \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$= (2)(9,8)(10) - 0 + 0 - \frac{1}{2}(2)(20^2) = -204$ J (4)

4.2.3 $W_f = F_f.\Delta x \cos\theta$

$-204 = (12)\ \Delta x \cos 180°$

$\Delta x = 17$ m

$\sin\theta = \frac{h}{\Delta x} = \frac{10}{17}$

$\theta = 36,03°$ (4)

[13]

Question 5

5.1.1 As the train approaches the motorist, the waves being emitted by the whistle catch up with the waves previously emitted. This results in more waves being present and a smaller wavelength. This decrease in wavelength is accompanied by an increased frequency, since the speed of the waves is constant. (4)

5.1.2 We are given $v_L = 0, f_S = 510$ Hz, $f_L = 540$ Hz, $v = 340\ \text{m·s}^{-1}$ and wish to find v_S.

Since the source is moving towards the stationary listener, we use the full Doppler Effect equation:

$$f_L = \frac{(v \pm v_L)}{(v \pm v_S)} f_S$$

to obtain:

$$f_L = \frac{(v)}{(v - v_S)} f_S$$

$$v_S = v\left(\frac{1 - f_S}{f_L}\right) = 340\ \text{m·s}^{-1}\left(\frac{1 - 510\ \text{Hz}}{540\ \text{Hz}}\right) = 19\ \text{m·s}^{-1}$$ (5)

5.1.3 The equation $f_L = \frac{(v)}{(v - v_S)} f_S$ shows that any increase in v_S will result in an increase in f_L if the other quantities remain fixed. The frequency of the sound heard by the motorist will be greater than 540 Hz if the train's speed is doubled. (3)

5.2.1 Away from Earth (1)

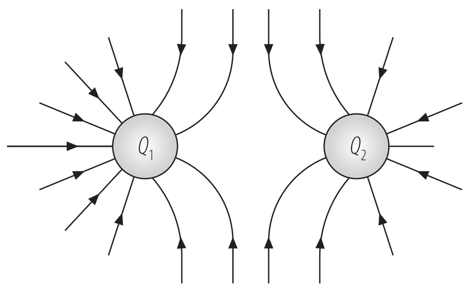
5.2.2 Diagram B shows that the spectrum of the element has been red-shifted, i.e. the frequencies have been shifted towards the lower end of the spectrum. Decreasing frequencies imply that the source is moving away from the observer. (4)

[17]

Question 6

6.1 $n = \frac{Q_1}{e} = \frac{-50 \times 10^{-9}\ \text{C}}{-1{,}6 \times 10^{-9}\ \text{C}} = 3{,}12 \times 10^{10}$ (2)

6.2

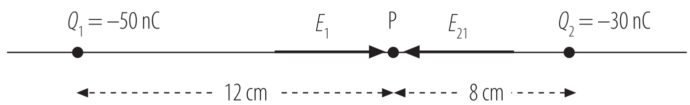


(2)

6.3 $F = k\frac{Q_1 Q_2}{r^2} = (9 \times 10^9\ \text{N·m}^2\text{·C}^{-2})\ \frac{50 \times 10^{-9}\ \text{C} \times 30 \times 10^{-9}\ \text{C}}{(20 \times 10^{-2}\ \text{m})^2}$

$= 3{,}8 \times 10^{-5}$ N to the right (4)

6.4 The distance from Q_1 to P is 12 cm and E_1 is directed to the right and E_2 directed to the left.



The magnitude of the resultant electric field is:

$$E_{net} = E_1 - E_2$$
$$= k\frac{Q_1}{r_1^2} - k\frac{Q_2}{r_2^2} = k(\frac{Q_1}{r_1^2} - \frac{Q_2}{r_2^2})$$
$$= 9 \times 10^9\ N \cdot m^2 \cdot C^{-2}(\frac{50 \times 10^{-9}\ C}{(12 \times 10^{-2}\ m)^2} - \frac{30 \times 10^{-9}\ C}{(8 \times 10^{-2}\ m)^2}) = -1,1 \times 10^4\ N \cdot C^{-1}$$

The resultant electric field is of magnitude $1,1 \times 10^4\ N \cdot C^{-1}$ and is directed to the left. (5)

[13]

Question 7

7.1 Emf = 24 V (1)

7.2 $P = \frac{V^2}{R} \rightarrow R = \frac{V^2}{P} = \frac{(6\ V)^2}{9\ W} = 4\ \Omega$ (2)

7.3 The current through R is:

$I = \frac{P}{V} = \frac{9\ W}{6\ W} = 1,5\ A$

The potential difference across the 6 Ω + 3 Ω = 9 Ω resistor is 6 V.

The current through this branch is $I = \frac{V}{R} = \frac{6\ V}{9\ \Omega} = 0,67\ A$.

The current through the ammeter is 1,5 A + 0,67 A = 2,17 A. (5)

7.4 The potential difference across the 7 Ω resistor is $V = IR = 2,17\ A \times 7\ \Omega = 15,2\ V$.

The potential difference across the internal resistance is 24 V – 6 V – 15,2 V = 2,8 V.

The internal resistance is $r = \frac{2,8\ V}{2,17\ A} = 1,3\ \Omega$. (4)

7.5 Increase (because the total resistance will increase and therefore V increases) (1)

[13]

Question 8

8.1 Slip rings, since the current is alternating (1)

8.2 2 A (1)

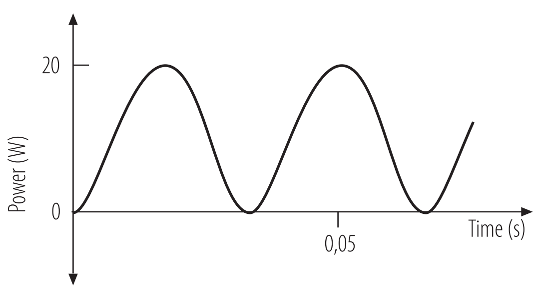
8.3 Horizontal (1)

8.4 T = time for one cycle = 0,05 s (from the graph)

frequency of rotation $= f = \frac{1}{T} = \frac{1}{0,05\ s} = 20$ (3)

8.5 $P_{max} = I_{max}V_{max} = 2\ A \times 10\ V = 20\ W$ (2)

8.6



(4)

[12]

Question 9

9.1 $P_{avg} = \frac{1}{2}P_{max}$

$P_{max} = 2P_{avg} = 2 \times 36\text{ W} = 72\text{ W}$ (3)

9.2 $P_{avg} = V_{rms}I_{rms}$

$I_{rms} = \frac{P_{avg}}{V_{rms}} = \frac{36\text{ W}}{220\text{ V}} = 0{,}16\text{ A}$

$I_{max} = \sqrt{2}I_{rms} = \sqrt{2} \times 0{,}16\text{ A} = 0{,}23\text{ A}$ (4)

9.3 $P_{avg} = \frac{V^2_{rms}}{R}$

$R = \frac{V^2_{rms}}{P_{avg}} = \frac{(220\text{ V})^2}{36\text{ W}} = 1\ 344\ \Omega$ (2)

9.4 Electric power has to be transmitted over long distances from the power stations to the users. If the power was transmitted as DC this would require a large amount of cabling and result in a very large loss of power in the form of $P = I^2R$. However, with the use of transformers, AC power can be transmitted at much larger voltages with a resulting decrease in current. This minimises the power losses. A transformer will not work if connected to a DC power source. (4)

[13]

Question 10

10.1 The photoelectric effect (1)

10.2 $KE_{max} = 5 \times 10^{-19}\text{ J}$ (2)

10.3 $KE_{max} = hf - W_0$

$W_0 = hf - KE_{max} = 6{,}63 \times 10^{-34}\text{ J·s} \times 1{,}75 \times 10^{15}\text{ Hz} - 5 \times 10^{-19}\text{ J}$

$= 6{,}6 \times 10^{-19}\text{ J}$ (4)

10.4 $f_0 = 1{,}0 \times 10^{15}\text{ Hz}$ (2)

10.5.1 Emission spectrum. This spectrum has coloured lines against a black background, while an emission spectrum will have dark lines against a coloured background. (3)

10.5.2 The transition between the ground state and the second excited state will involve the largest energy difference and from $\Delta E = hf = \frac{hc}{\lambda}$ we notice that the largest energy difference will correspond to the smallest wavelength, which is 414 nm. (4)

[16]

TOTAL: 150