TU Delft

Faculty of Aerospace Engineering

RESIT EXAM: WAVES and ELECTROMAGNETISM (AE1240-II)

10 August 2015, 14:00 – 17:00 — 9 pages

Please read these instructions first:

1) This exam contains 25 four-choice questions. Please mark one answer per question on the 'Four Choice Response Form'.

2) **If you want to correct your answer, mark a new box and draw a cross through the originally marked box.** In case of more corrections per answer it is recommended to ask for a new form, since the forms are processed automatically.

3) Do not forget to write your **name** and **7-digit student number**. Also mark your student number in the corresponding box. If these are missing, the exam result is invalid! Finally sign the form.

4) Use of the book "Physics for Scientists & Engineers with modern physics" (volume II), by Giancoli, copies of lectures slides or any other material (cell phones, etc.) is not allowed. Only the use of your (graphical) pocket calculator is allowed.

5) **Please do not turn over the page before 14:00.**

Question 1

When a mass of 180 g is attached to a vertical spring and lowered to its equilibrium position, it is found that the spring extends 12 cm. If the mass is now displaced from its equilibrium position, what is the period of the resulting oscillations?

(A) 0.69 s
(B) 1.5 s
(C) 2.2 s
(D) 3.7 s

Question 2

A simple harmonic oscillator has an amplitude of 3.50 cm and a maximum speed of 28.0 cm/s. What is its speed when the displacement is 1.75 cm?

(A) 14.2 cm/s
(B) 17.0 cm/s
(C) 21.3 cm/s
(D) 24.2 cm/s

Question 3

A 2.00 kg mass oscillates on the end of a spring with spring constant 12.0 N/m. Its amplitude of oscillation decreases from 10.0 cm to 1.0 cm in 4.00 minutes. What is the linear damping coefficient of this oscillator?

(A) 0.0384 Nsm^{-1}
(B) 0.311 Nsm^{-1}
(C) 0.622 Nsm^{-1}
(D) 1.76 Nsm^{-1}

Question 4

What is the speed of the wave described by $y(x,t) = A\cos(x^2 + 2Bxt + B^2t^2)$.

(A) $B/2$
(B) B
(C) B^2
(D) the function given is not a solution to the wave equation

Question 5

A 60.0 cm long string with a mass of 8.00 g has a tension of 200 N. What is the fundamental frequency of this string?

(A) 3.75 Hz
(B) 38.7 Hz
(C) 56.7 Hz
(D) 102 Hz

Question 6

A pipe of length *L* closed at one end is resonating at its fundamental frequency. Which statement is correct?

(A) The wavelength is 4*L* and there is a displacement node at the pipe's open end.
(B) The wavelength is 4*L* and there is a displacement antinode at the pipe's open end.
(C) The wavelength is 2*L* and there is a displacement node at the pipe's open end.
(D) The wavelength is 2*L* and there is a displacement antinode at the pipe's open end.

Question 7

Two pure tones sound together and a particular beat frequency is heard. What happens to the beat frequency if the frequency of one of the tones is increased?

(A) it increases
(B) it decreases
(C) it could either increase or decrease
(D) it does not change

Question 8

Two people are talking at a distance of 3.0 m from where you are and you measure the sound intensity as 1.1×10^{-7} W/m^2. Another student is 4.0 m away from the talkers. What sound intensity does the other student measure?

(A) 3.5×10^{-8} W/m^2
(B) 6.2×10^{-8} W/m^2
(C) 8.3×10^{-8} W/m^2
(D) 1.5×10^{-7} W/m^2

Question 9

If the intensity level of one trombone is 70 dB, what is the intensity level of 76 trombones?

(A) 76 dB
(B) 89 dB
(C) 103 dB
(D) 146 dB

Question 10

A policeman in a stationary car measures the speed of approaching cars by means of an ultrasonic device that emits a sound with a frequency of 41.2 kHz. A car is approaching him at a speed of 33.0 m/s. The wave is reflected by the car and interferes with the emitted sound producing beats. What is the frequency of the beats? The speed of sound in air is 330 m/s.

(A) 4.1 kHz
(B) 4.6 kHz
(C) 8.2 kHz
(D) 9.2 kHz

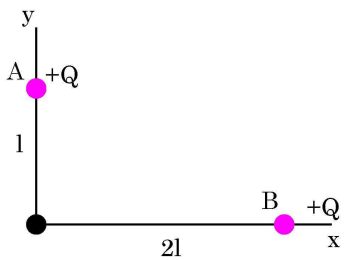
Question 11

A supersonic plane passes overhead at a speed of 500 m/s. If you hear the sonic boom (shock wave) 4.00 s after the plane is directly overhead, at what altitude is the plane flying? Assume the speed of sound in air is 340 m/s.

(A) 1.36 km
(B) 1.85 km
(C) 2.16 km
(D) 2.45 km

Question 12

A charge $+Q$ is placed at a distance l on the positive y-axis and a charge $+Q$ is placed at a distance $2l$ on the positive x-axis as shown in the figure. Determine the magnitude of the electric field at the origin.



(A) $\dfrac{Q\sqrt{17}}{16\pi\varepsilon_0 l^2}$ (B) $\dfrac{Q\sqrt{5}}{8\pi\varepsilon_0 l^2}$

(C) $\dfrac{5Q}{16\pi\varepsilon_0 l^2}$ (D) $\dfrac{2Q}{4\pi\varepsilon_0 (3l/2)^2}$

Question 13

A point charge q = +1 μC is located at the origin. What is the flux of the electric field of this charge through a square whose corners are:
(x, y, z) = (1, 1, 1), (-1, 1, 1), (-1, 1, -1) and (1, 1, -1)?
(x, y and z in m)

(A) 11.3×10^4 Nm^2/C
(B) 3.8×10^4 Nm^2/C
(C) 1.9×10^4 Nm^2/C
(D) 1.0×10^4 Nm^2/C

Question 14

The electric potential of a charge distribution is given by $V(x, y) = 2xy - x^2 - y$. At which point is the electric field equal to zero?

(A) (x,y) = (1, 1)
(B) (x,y) = (1, 0.5)
(C) (x,y) = (0.5, 1)
(D) (x,y) = (0.5, 0.5)

Question 15

Two charges $Q_A = +q$ and $Q_B = -3q$ are located on the x-axis at $x = 0$ and $x = d$, respectively. Where is the electric potential equal to zero?

(A) $x = d/4$
(B) $x = d/3$
(C) $x = 2d/3$
(D) $x = 3d/4$

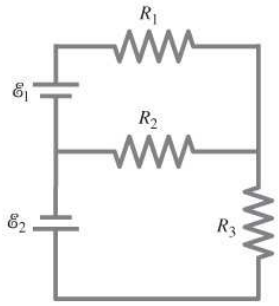
Question 16

A 4.0 μF and a 6.0 μF capacitor are connected in series across an 8.0 volt DC source. What is the charge on the 6.0 μF capacitor?

(A) 19 μC
(B) 25 μC
(C) 32 μC
(D) 48 μC

Question 17

Determine the magnitude of the current through resistor R_3 of the circuit shown in the figure. The batteries have EMFs of $\mathcal{E}_1 = 8.8$ V and $\mathcal{E}_2 = 11.7$ V. The resistors have values of R_1 = 32 Ω, R_2 = 40 Ω and R_3 = 36 Ω. Ignore internal resistances of the batteries.



(A) 0.22 A
(B) 0.18 A
(C) 0.13 A
(D) 0.10 A

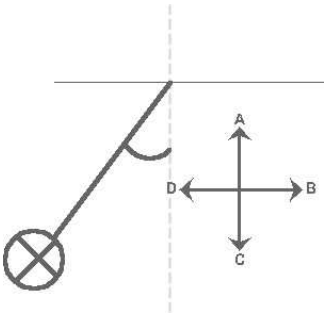
Question 18

A galvanometer has a coil with a resistance of 24.0 Ω. A current of 180 μA causes full-scale deflection. If the galvanometer is to be used to construct an ammeter that deflects full scale for 10.0 A, what shunt resistor is required?

(A) 123 μΩ
(B) 234 μΩ
(C) 342 μΩ
(D) 432 μΩ

Question 19

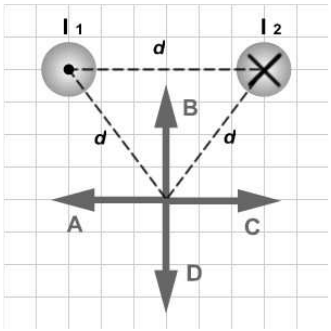
A horizontal, long current-carrying wire is hanging from a vertical thread. The current is oriented into the plane of the figure shown below. A uniform magnetic field is applied and the wire is pulled away from the vertical. Which of the arrows labeled A to D correctly indicates the direction of the magnetic field?



(A) A
(B) B
(C) C
(D) D

Question 20

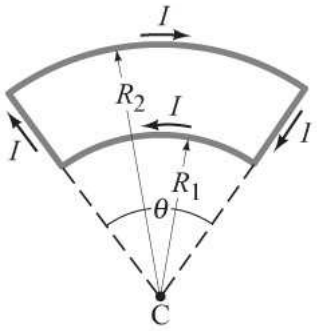
The figure below shows two long wires carrying equal currents I_1 and I_2 flowing in opposite directions. Which of the arrows labeled A to D correctly represents the direction of the magnetic field due to the wires at a point located at an equal distance *d* from each wire?



(A) A
(B) B
(C) C
(D) D

Question 21

A wire in a plane has the shape as shown in the figure: two arcs of a circle connected by radial lengths of wire. What is the magnitude of the magnetic field at the point C expressed in terms of R_1, R_2, θ and I?



(A) $\frac{\mu_0 I\theta}{8\pi}\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$

(B) $\frac{\mu_0 I\theta}{8\pi}\left(\frac{1}{R_1^2}-\frac{1}{R_2^2}\right)$

(C) $\frac{\mu_0 I\theta}{8\pi}\left(\frac{1}{R_1^2}+\frac{1}{R_2^2}\right)$

(D) $\frac{\mu_0 I\theta}{4\pi}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

Question 22

A loop of diameter d = 10 cm, carrying a current I = 0.2 A, is placed inside a magnetic field $\vec{B} = 0.3\ \mathrm{T}\,\hat{k}$. The normal to the loop is parallel to a unit vector $\hat{n} = -0.6\hat{\imath} - 0.8\hat{\jmath}$. Calculate the magnitude of the torque on the loop.

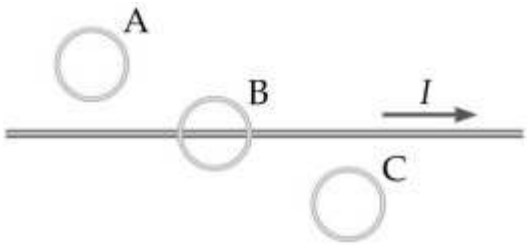
(A) 0
(B) 1.2×10^{-4} Nm
(C) 2.8×10^{-4} Nm
(D) 4.7×10^{-4} Nm

Question 23

The magnetic permeability of a ferromagnetic material is

(A) much greater than μ_0
(B) slightly more than μ_0
(C) slightly less than μ_0
(D) much less than μ_0

Question 24

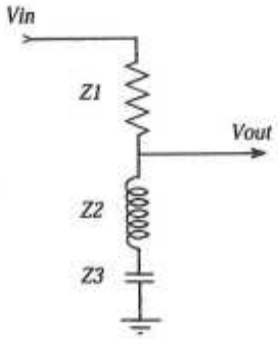


The wire in the figure carries a current *I*, that is increasing in time at a constant rate. The induced emf in each loop is such that

(A) no emf is induced in any loop.
(B) loop A has a clockwise emf, loop B has no induced emf and loop C has a counterclockwise emf.
(C) loop A has a counterclockwise emf, loop B has no induced emf and loop C has a clockwise emf.
(D) loop A has a clockwise emf, loop B has a clockwise emf and loop C has a counterclockwise emf.

Question 25

The figure below shows a circuit called a notch filter, used to remove a narrow band of frequencies. Here R = 50 Ω, C = 470 pF and L = 54 μH. At which frequency is the voltage gain V_{out}/V_{in} = 0 , i.e. which frequency is totally eliminated?



(A) 0.32 MHz
(B) 1.0 MHz
(C) 3.1 MHz
(D) 6.3 MHz