DEPARTMENT & COURSE NO.: PHYS 1070 TIME: 2 hours

EXAMINATION: Physics 2: Waves and Modern Physics EXAMINERS: G. Gwinner and J. Mammei

All questions are of equal value. Answer all questions. No marks are subtracted for wrong answers.

Record all answers on the computer score sheet provided. **USE PENCIL ONLY!** Black pen will look good but may not be read reliably by the scoring machine. **Mark only <u>one</u> answer for each question!** Select the answer that is closest to yours.

"n.o.t." denotes "none of these" choices.

A formula sheet is provided for your use; you may **not** use your own formula sheet or any other materials or notes. Calculators of any type are allowed, but not devices that store text or that can communicate with other such devices.

Be sure your name and student number are printed on the score sheet and the student number correctly coded in the box at the top right-hand side of the sheet.

This is paper A. Questions are numbered 1 to 20. Mark the correct answers in rows 1-20 of the ***first*** column of the accompanying IBM sheet in pencil. Also write "Paper A" next to your name on the IBM sheet.

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1. An object with mass m is attached to the end of a horizontal spring and oscillates with a period of 0.5 seconds. If the object is suspended from the same spring vertically, by how much is the spring stretched from its natural length when the object is at the equilibrium position?

   (a) 0.062 cm (b) 12.4 cm (c) 6.2 cm (d) 0 cm (e) 3.1 cm

2. A particle is undergoing simple harmonic motion with displacement $x(t) = x_m \cos(\omega t + \varphi)$. When the kinetic energy is equal to five times the potential energy, and the acceleration a_x is positive, the displacement is:

   (a) $x_m / \sqrt{5}$ (b) $x_m / \sqrt{6}$ (c) $\pm x_m / \sqrt{5}$ (d) $-\sqrt{6}\, x_m$ (e) $-x_m / \sqrt{6}$

3. A vertical mass-on-a-spring oscillator has an oscillation period of 1 s on earth. It is transported to the moon, where the gravitational acceleration is six times less than on earth. The oscillation period on the moon is:

   (a) 36 s (b) 6 s (c) 1 s (d) $\frac{1}{6}$ s (e) $\sqrt{6}$ s

4. For an oscillator subjected to a damping force proportional to its velocity:

   (a) the displacement is of the form $x(t) = x_m \cos(\omega t + \phi_1)$.

   (b) the mechanical energy is constant.

   (c) the frequency is a decreasing function of time.

   (d) the velocity is of the form $v(t) = v_m \cos(\omega t + \phi_2)$.

   (e) none of the above is true.

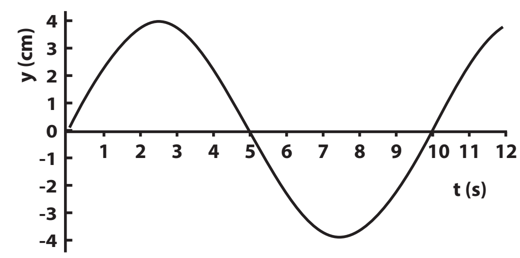
5. A mass (m = 1.0 kg) on a spring is undergoing simple harmonic motion with frequency f = 2.0 Hz. The total mechanical energy of this oscillator is E = 0.20 J. The amplitude of the motion is

   (a) 5.0 cm (b) 0.25 cm (c) 50 cm (d) 32 cm (e) 18 cm

6. A particle is undergoing simple harmonic motion with displacement $x = x_m \cos(\omega t + \varphi)$ at a frequency of $f = 0.1$ Hz. The potential energy of the particle is maximum at time $t = 0.32$ s. This is consistent with the phase constant:

(a) 0.20 rad (b) -0.20 rad (c) -0.79 rad (d) 0.79 rad (e) 0 rad

7. A sinusoidal traveling wave $y = y_m \sin(kx \pm \omega t + \varphi)$, with wavelength $\lambda = 20$ cm and phase constant $\varphi = 0$, travels along a string that is stretched along the x-axis. The displacement of the string at $x = 0$, i.e. $y(0, t)$ is shown in the graph. The speed and direction of travel of the wave are:



(a) 1 cm/s towards (-x) (b) 0.4 cm/s towards (-x) (c) 1 cm/s towards (+x) (d) 2 cm/s towards (-x)
(e) 2 cm/s towards (+x)

8. A simple harmonic wave of wavelength 10.0 cm and amplitude 0.40 cm travels along a wire of linear mass density 0.015 kg/m. The maximum transverse speed of any point on the wire is 628 cm/s. the tension in the string is:

(a) 6.6 N (b) 5.6 N (c) 9.4 N (d) 11.2 N (e) 7.9 N

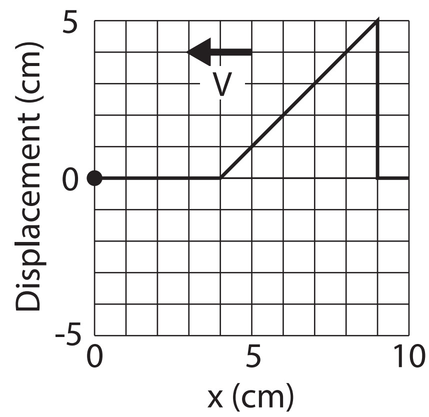
9. The shape of a wave on a string is given at time $t = 0$ by the function

$y = 2x / (x^2 + 50)$ (with x, y in cm).

The waveform is travelling in the positive x direction (without changing shape) at a propagating speed of 10.0 cm/s. At time $t = 5.0$ s the displacement of the string (in cm) at location $x = 30.0$ cm is:

(a) 0.063 (b) -0.089 (c) 0.025 (d) -0.039 (e) 0.039

10. A string under tension has fixed end at location $x = 0$. A triangular wave pulse, shown in the figure at time $t = 0$, is moving toward the fixed end of the string at a speed of 1.0 cm/s. What is the displacement of a point on the string at location $x = 1.0$ cm and time $t = 7.0$ s?



(a) -2.0 cm (b) 2.0 cm (c) -3.0 cm (d) 4.0 cm
(e) 0

11. Piano strings are strings fixed at both ends and held under tension. In certain ranges of a piano keyboard, more than one string is tuned to the same note to provide extra loudness. For example, the note at 110 Hz has two identical strings at this pitch. If one of these strings slips from its normal tension of 600 N to 540 N, what beat frequency will be heard when the two strings are struck simultaneously (so that each vibrates in the same harmonic)?

(a) 5.6 Hz (b) 8.3 Hz (c) 11 Hz (d) 22 Hz (e) 89 Hz

12. A wave travelling on a string under tension is delivering an average power of 2.0 W. A wave of the same frequency and amplitude travelling on a string of twice the linear mass density under the same tension would deliver a power of

(a) 1.0 W (b) 4.0 W (c) 2.8 W (d) 1.4 W (e) 2.0 W

13. The total disturbance on a string is due to the superposition of two harmonic waves, $y = y_m \sin(kx - \omega t + \varphi)$, each of amplitude 1.00 cm. The two waves are identical in all respects except for their phase constants: $\varphi_1 = -15°$ and $\varphi_2 = -75°$. At time $t = 0$ the displacement of the string at $x = 0$ is:

(a) 2.00 cm (b) -1.41 cm (c) 1.73 cm (d) 0 (e) -1.22 cm

14. A 200 cm long organ pipe, open at both ends, is in resonance with a sound wave of wavelength 200 cm. The pipe is operating at its

(a) fifth harmonic (b) fourth harmonic (c) third harmonic
(d) second harmonic (e) fundamental frequency

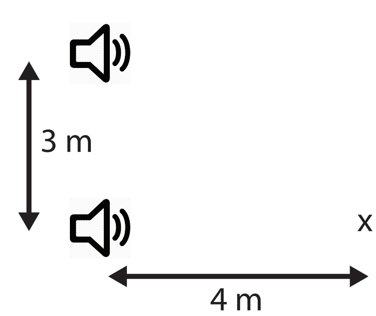
15. A point source emits sound isotropically. A small microphone of cross-sectional area 0.750 cm^2 intercepts the sound at a distance of 200 m away and registers a power of 3.00×10^{-9} W. With what average power is the source radiating?

(a) 30.0 W (b) 13.5 W (c) 6.00 W (d) 20.1 W (e) 9.00 W

16. A spherical sound wave is emitted by a point source. Relative to the sound level 1 m from the source, the sound level 5 m from the source is about:

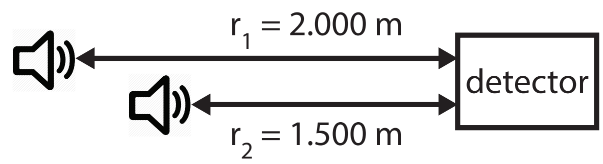
(a) 0 dB (b) – 7dB (c) +7 dB (d) -14 dB (e) +14 dB

17. Two small identical speakers are connected (in phase) to the same source. The speakers are 3 m apart and at ear level. An observer stands at point X, 4 m in front of one speaker as shown. The sound she hears is most intense if the wavelength is



(a) 2 m (b) 3 m (c) 1 m (d) 4 m
(e) 5 m

18. Two loudspeakers are arranged, as shown in the figure, such that the sound waves they generate travel straight-line paths of lengths r_1 and r_2 to a microphone detector. The loudspeakers are driven by signals of the same frequency which are not in-phase, so that the pressure waves striking the microphone are given by



$$\Delta p_1 = \Delta p_m \sin(kr_1 - \omega t) \quad \text{and}$$
$$\Delta p_2 = \Delta p_m \sin(kr_2 - \omega t + \varphi).$$

With $r_1 = 2.000$ m, $r_2 = 1.500$ m and $k = 9.16$ m^{-1}, find the phase constant, φ, necessary to produce destructive interference at the detector.

(a) -1.704 rad (b) 1.571 rad (c) 3.142 rad (d) 1.438 rad (e) 4.580 rad

19. A tube, A, has one closed end and length L while open tube, B, has length $L' = 4L/3$. The fundamental resonance of tube A is at a frequency of 300 Hz. Find the minimum frequency at which both tube A and B resonate.

(a) 1200 Hz (b) 300 Hz (c) 1500 Hz (d) 600 Hz (e) 900 Hz

20. A source emits a sound with a frequency of 1000 Hz. Both it and an observer are moving away from each other, with a speed of 100 m/s with respect to air. If the speed of sound is 340 m/s, the observer hears a sound with a frequency of

(a) 294 Hz (b) 545 Hz (c) 1000 Hz (d) 1833 Hz (e) 3400 Hz

THE END