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GLASGOW COLLEGE UESTC

Exam paper

Physics I (UESTC1009)

Date: 4th,September 2020
Time: 16:30-18:30PM

Attempt all PARTS. Total 100 marks

Use one answer sheet for each of the questions in this exam.
Show all work on the answer sheet.
For Multiple Choice Questions, use the dedicated answer sheet provided.

Make sure that your University of Glasgow and UESTC Student Identification Numbers are on all answer sheets.

An electronic calculator may be used provided that it does not allow text storage or display, or graphical display.

All graphs should be clearly labelled and sufficiently large so that all elements are easy to read.

The numbers in square brackets in the right-hand margin indicate the marks allotted to the part of the question against which the mark is shown. These marks are for guidance only.

Glasgow College, UESTC

Physics I -Semester 2, 2019 - 2020

Final Exam (A)

Q1 Multiple choice

Choose the ONE alternative that best complete the statement or answer the questions.

1. (   ) A rigid body is acted on by two external forces which have the same magnitude but opposite direction. [3]

(A) The momentum of the body is conserved.

(B) The mechanical energy of the body is conserved.

(C) The angular momentum of the body is conserved。

(D) The momentum, mechanical energy and the angular momentum are not conserved.

2. (   ) What is the phase ϕ for a simple harmonic motion with its speed $v(t)$ given in Fig. Q1-2 if the position $x(t)$ has the form $x = A\cos(\omega t + \phi)$? [3]

(A) $\frac{\pi}{4}$ (B) $\frac{3\pi}{4}$ (C) $-\frac{\pi}{4}$ (D) $-\frac{3\pi}{4}$

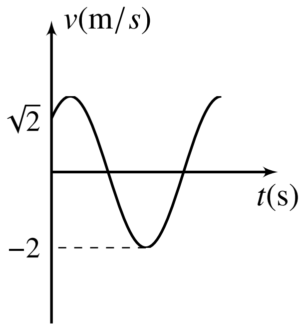

Figure Q1-2

3. (   ) Which of the following plane harmonic waves may form a standing wave $y = 0.2\sin 2\pi x\cos 20\pi t$. All quantities are in SI units. [3]

(A) $y_1 = 0.1\cos\left[2\pi(10t - x) + \frac{1}{2}\pi\right]$

$y_2 = 0.1\cos\left[2\pi(10t + x) + \frac{1}{2}\pi\right]$

(B) $y_2 = 0.1\cos\left[2\pi(10t + x) + 0.25\pi\right]$

$y_1 = 0.1\cos\left[2\pi(10t + x) + 0.75\pi\right]$

(C) $y_1 = 0.1\cos\left[2\pi(10t - x) + \frac{1}{2}\pi\right]$

$y_2 = 0.1\cos\left[2\pi(10t + x) - \frac{1}{2}\pi\right]$

(D) $y_1 = 0.1\cos\left[2\pi(10t - x) + 0.75\pi\right]$

$y_2 = 0.1\cos\left[2\pi(10t + x) - 0.75\pi\right]$

4. (   ) The intensity of an earthquake wave is $2.2\times 10^6\ \mathrm{W/m^2}$ at a distance of 100 km from the source. What was the intensity when it passed a point only 4.0 km from the source? [3]

(A) $1\times 10^6\ \mathrm{W/m^2}$ (B) $1\times 10^9\ \mathrm{W/m^2}$

(C) $1.4\times 10^9\ \mathrm{W/m^2}$ (D) $1.4\times 10^{12}\ \mathrm{W/m^2}$

5. (   ) Sources A and B emit long-range radio waves of wavelength 400 m, with the phase of the emission from A ahead of that from source B by 90°. The distance r_A from A to detector D is greater than the corresponding distance r_B by 100 m (Fig. Q1-5). What is the phase difference of the waves at D? [3]

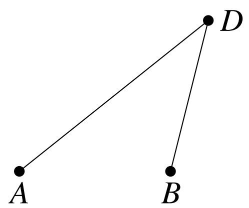

Figure Q1-5

(A) 0 (B) $\frac{\pi}{2}$ (C)π (D) $\frac{3\pi}{2}$

6. ( ) The wave function of a plane harmonic wave is

$$y = 0.02\cos(5\pi x - 200\pi t) \quad \text{(in SI units)}$$

the frequency of the wave f and the speed of the wave is v are [3]

(A) $f = 50\,\mathrm{Hz}, v = 40\,\mathrm{m/s}$ (B) $f = 100\,\mathrm{Hz}, v = 40\,\mathrm{m/s}$

(C) $f = 100\,\mathrm{Hz}, v = 20\,\mathrm{m/s}$ (D) $f = 50\,\mathrm{Hz}, v = 20\,\mathrm{m/s}$

7. ( ) A particle (mass m) moves through an xyz coordinate system. The position vector is

$$\vec{r} = A\cos\omega t\,\hat{i} + B\sin\omega t\,\hat{j}$$

where A, B and ω are constants, all quantities are in SI units. The angular momentum of the particle about the origin L and the torque of the net force about the origin τ are [3]

(A) $L = 0, \tau = mAB\omega^2$ (B) $L = mAB\omega, \tau = mAB\omega^2$

(C) $L = mAB\omega, \tau = 0$ (D) $L = 0, \tau = 0$

8. ( ) Light of wavelength 624 nm is incident perpendicularly on a soap film ($n = 1.33$) suspended in air, What are the least thickness of the film for which the reflections from the film undergo fully constructive interference? [2]

(A) $0.117\,\mu\mathrm{m}$ (B) $0.234\,\mu\mathrm{m}$ (C)$0.352\,\mu\mathrm{m}$ (D) $0.480\,\mu\mathrm{m}$

9. ( ) A slit is illuminated by light of wavelength 633 nm, the screen is 6.0 m away. The distance between two first maxima is 32 mm. How wide is the slit? [2]

(A) 0.176 mm (B) 0.356 mm (C)0.532 mm (D) 0.888 mm

Q2 (1) Rotational inertia. Two thin rods (each of mass m) are joined together to form a rigid body as shown in Fig. Q2-1. One of the rods has length L_1 , and the other has length L_2 . Find

(a) the rotational inertia of this rigid body I_A about an axis that is perpendicular to the plane of the paper and passes through A. [4]

(b) the rotational inertia I_B about an axis that is perpendicular to the plane of the paper and passes through B. [4]

(2) Fig. Q2-2 shows a uniform solid sphere of mass M and radius R can rotate about a vertical axis on a frictionless bearing. A massless cord passes around the equator of the shell, over a pulley of moment of inertia I and radius r, and is attached to a small object of mass m. There is no friction on the pulley's axle; the cord does not slip on the pulley.

(a) Show the moment of inertia of a uniform solid sphere of mass M and radius R is $\frac{2}{5}MR^2$.[3]

(b) What is the acceleration of the small object due to its weight? [7]

(c) What is the speed of the object when it has fallen H after being released from rest? Use energy considerations. [7]

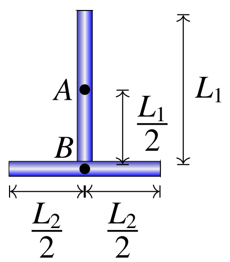

Figure Q2-1

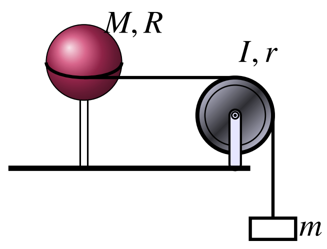

Figure Q2-2

Q3 (1) Interference of light. How far must the mirror of the Michelson interferometer be moved so that 1800 fringes of He-Ne laser light (its wavelength $\lambda = 633$ nm) move across a line in the field of view? (see Fig. Q3-1) [10]

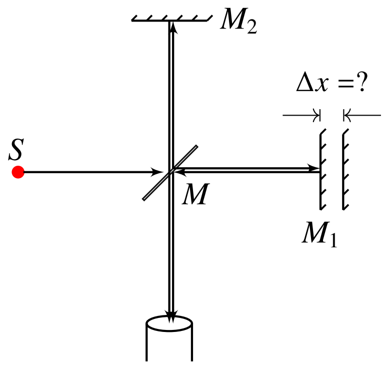

Figure Q3-1

(2) Diffraction of light. The wavelengths of the visible spectrum are approximately 380 nm (violet) to 750 nm (red).

(a) Find the angular limits of the first order visible spectrum produced by a plane grating with 600 slits per millimeter when white light falls normally on the grating. [8]

(b) Do the second-order and third-order spectra overlap? Why or why not? [7]

Q4 (1) Wave motion. The wave function of a plane harmonic wave is

$$y = 0.1\cos(2\pi x - 200t) \quad \text{(in SI units)}$$

(a) What's the wavelength of the wave? [3]

(b) What's the maximum speed of the point at $x = 0.15\,\mathrm{cm}$? [3]

(c) What's the direction of the propagation? [2]

(2) Simple harmonic motion. A particle moves on $+x$ axis. If its potential energy is in the form of

$$U = -2b\left(\frac{a}{x}\right)^6 + b\left(\frac{a}{x}\right)^{12}$$

where x is the coordinate, a and b are positive constants.

(a) Determine the value x_0 where particle has a minimum potential energy? [5]

(b) If the particle undergoes a small-amplitude oscillations around x_0, i.e, $|x - x_0| \ll x_0$, show it must be a simple harmonic oscillation. Find out its frequency. (Hints: use Taylor series.)[12]