UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2007/2008

April 2008

ZCT 103/3 – Physics III (Vibration, Waves and Optics)
[Fizik III (Getaran, Gelombang dan Optik)]

Duration: 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains **TEN** printed pages before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **SEPULUH** muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]*

Instruction: Answer **all FIVE (5)** questions. Students are allowed to answer all questions in Bahasa Malaysia or in English.

*[**Arahan**: Jawab **semua LIMA (5)** soalan. Pelajar dibenarkan menjawab semua soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]*

.../2-

1) (a) Fig. 1 illustrates the damped simple harmonic motion (SHM) system.
[Rajah. 1 menunjukkan sistem gerak harmonic mudah (GHM) terlembab.]

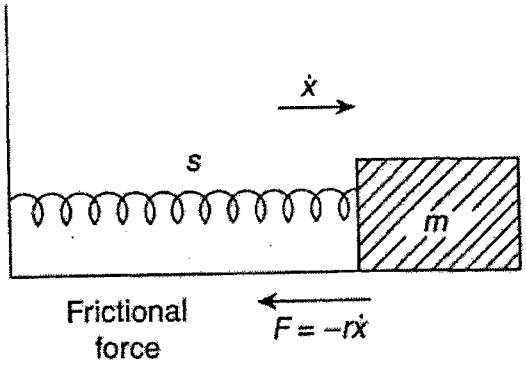

Figure 1 *[Rajah 1]*

For heavy damped SHM system, show that the expression can be written as
[Untuk sistem GHM rentak mati, tunjukkan yang ungkapan dapat dituliskan sebagai]

$$x = e^{-pt}(C_1 e^{qt} + C_2 e^{-qt})$$

Where C_1, C_2 are constant, $p = \frac{r}{2m}$ and $q = \left(\frac{r^2}{4m^2} - \frac{s}{m}\right)^{\frac{1}{2}}$, r and s are the resistive constant and stiffness, respectively. Other symbols have their usual meaning.

[Di sini C_1, C_2 adalah pemalar, $p = \frac{r}{2m}$ dan $q = \left(\frac{r^2}{4m^2} - \frac{s}{m}\right)^{\frac{1}{2}}$, r dan s adalah pemalar rintangan dan kekakuan, masing-masing. Simbol-simbol lain mempunyai maksud yang biasa.]

(60/100)

(b) The frequency square of a damped SHM system is given by
[Kuasa dua frekuensi bagi system GHM terlembab diberikan oleh]

$$\omega'^2 = \frac{s}{m} - \frac{r^2}{4m^2} = \omega_0^2 - \frac{r^2}{4m^2}$$

(i) If $\omega_0^2 - \omega'^2 = 10^{-6}\omega_0^2$, determine the quality factor Q and logarithmic decrement δ.
[Jika $\omega_0^2 - \omega'^2 = 10^{-6}\omega_0^2$, tentukan faktor kualiti Q dan susutan logarithmik δ.]

(ii) If $\omega_0 = 10^6\ s^{-1}$ and m $=10^{-10}$ kg, determine the stiffness *s* and resistive constant *r* of the system.
[Jika $\omega_0 = 10^6\ s^{-1}$ and $m = 10^{-10}$ kg, tentukan kekakuan s and pemalar rintangan r bagi sistem.]

(iii) If the maximum displacement at $t = 0$ is 10^{-2} m, determine the energy *E* of the system and the time *t* when energy decays to e^{-1}.
[Jika sesaran maksima pada t = 0 ialah 10^{-2} m, tentukan tenaga E bagi sistem dan masa t apabila tenaga menyusut kepada e^{-1}.]

(iv) Find the energy loss in the first cycle.
[Dapatkan tenaga yang hilang dalam kitar pertama.]

(40/100)

2) (a) Give the important characteristics of transverse waves and longitudinal waves.
[Berikan sifat-sifat penting bagi gelombang melintang dan gelombang membujur.]

(20/100)

(b) A string consists of two sections smoothly joined at a point $x = 0$ with a constant tension τ along the whole string. The two sections have different linear densities ρ_1 and ρ_2. An incident wave $y_i = A_i e^{j\omega(t-x/c_1)}$ traveling along the string meets the discontinuity in impedance at the position $x = 0$ as shown in Figure 2 below. Note that c is the wave velocity, $j = \sqrt{-1}$, other symbols have their usual meaning.

[Suatu tali mempunyai dua bahagian yang tersambung dengan baik pada suatu titik $x = 0$ dengan pemalar ketegangan τ sepanjang keseluruhan tali tersebut. Kedua-dua bahagian tali mempunyai ketumpatan linear ρ_1 and ρ_2. Suatu gelombang datang $y_i = A_i e^{j\omega(t-x/c_1)}$ bergerak sepanjang tali bertemu ketakselanjaran rintangan pada kedudukan $x = 0$ seperti ditunjukkan dalam Rajah 2 di bawah ini. Ambil perhatian bahawa c ialah halaju gelombang, $j = \sqrt{-1}$, simbol lain mempunyai maksud yang biasa.]

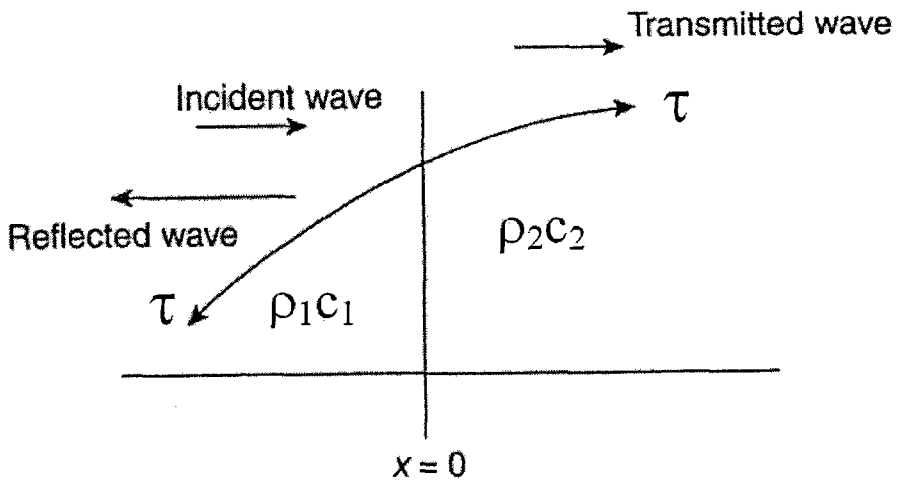

Figure 2 *[Rajah 2]*

(i) Write the expressions for the reflected wave and transmitted wave.
[Tulis ungkapan-ungkapan bagi gelombang terpantul dan gelombang terpancar.]

(ii) State the boundary conditions which apply at $x = 0$
[Nyatakan syarat-syarat sempadan yang digunakan pada x = 0]

(iii) Derive the reflection and transmission amplitude coefficients.
[Terbitkan pekali amplitud pantulan dan pekali amplitud pemancaran]

(50/100)

(c) Two strings with same tension τ but different linear densities ρ_1 and ρ_2 are joined at a particular point. Consider a wave travels along the string and meets the boundary. Determine the:-
[Dua tali dengan ketegangan τ yang sama tetapi mempunyai ketumpatan linear ρ_1 dan ρ_2 berlainan disambungkan pada suatu titik. Timbangkan suatu gelombang bergerak sepanjang tali dan menemui sempadan ini. Tentukan:-]

(i) ratio of reflected and incident amplitudes
[nisbah bagi amplitud-amplitud terpantul and datang]

(ii) ratio of transmitted and incident amplitudes
[nisbah bagi amplitude–amplitud terpancar dan datang]

in the cases of $\rho_2/\rho_1 = 0, 0.25, 1, 4, \infty$.
[dalam kes-kes bagi $\rho_2/\rho_1 = 0, 0.25, 1, 4, \infty$.]

(30/100)

3) (a) (i) State the Doppler effect.
[Nyatakan kesan Doppler.]

(ii) Give two important applications of Doppler effect.
[Beri dua kegunaan penting kesan Doppler]

(20/100)

(b) A driver travels northbound on a highway at a speed of 70 km/h. A police car, traveling southbound at a speed of 120 km/h, approaches the driver with its siren producing sound at a frequency of 2,500 Hz.
[Seorang pemandu bergerak ke arah utara di lebuhraya dengan kelajuan 70 km/h. Sebuah kereta polis, bergerak ke selatan pada kelajuan 120 km/h, menghampiri pemandu tersebut dengan siren dibunyikan pada frekuensi 2,500 Hz.]

(i) What frequency does the driver observe as the police car approaches?
[Apakah frekuensi pemandu memerhati apabila kereta polis menghampiri?]

(ii) What frequency does the driver detect after the police car passes him?
[Apakah frekuensi pemandu mengesan setelah kereta polis melalui pemandu?]

(iii) Repeat parts (i) and (ii) for the case when the police car is traveling northbound.
[Ulang bahagian (i) dan (ii) bagi kes apabila kereta polis sedang bergerak ke utara.]

Note: The speed of the sound is given as 343 m/s.
[Nota: Kelajuan bunyi ialah 343 m/s.]

(40/100)

(c) Figure 3 shows a pattern of resonant oscillation of a string of mass $m = 2.50$ g and $L = 0.80$ m and that is under tension $\tau = 325$ N.
[Rajah 3 menunjukkan suatu corak getaran resonans bagi suatu tali berjisim $m = 2.50$ g dan $L = 0.80$ m mempunyai tegangan $\tau = 325$ N.]

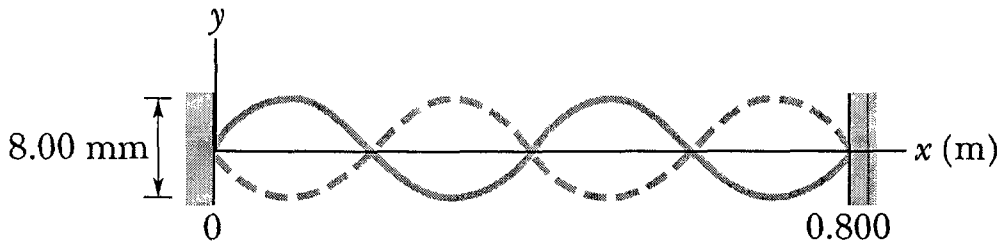

Figure 3 *[Rajah 3]*

(i) What is the wavelength λ of the transverse waves producing the standing wave pattern, and what is the harmonic number n?
[Berapakah jarak gelombang λ bagi gelombang melintang yang menghasilkan corak gelombang pegun, dan berapakah nombor harmonik n?]

(ii) What is the frequency f of the transverse waves?
[Berapakah frekuensi f bagi gelombang melintang?]

(iii) What is the maximum magnitude of the transverse velocity of the element oscillating at coordinate $x = 0.180$ m?
[Berapakah magnitud maksima halaju melintang bagi unsur yang bergetar pada koordinat $x = 0.180$ m?]

(iv) At which point during the element's oscillation is the transverse velocity maximum?
[Pada titik manakah semasa getaran unsur, halaju melintang adalah maksima?]

(40/100)

4) (a) Give a brief account of the nature of light. (You should discuss about the important characteristics of light, and give some examples for the dual nature of light)
[Jelaskan dengan ringkas tentang sifat cahaya. (Bincangkan tentang ciri-ciri penting cahaya, dan beri contoh-contoh untuk sifat dual cahaya)]

(30/100)

(b) Explain briefly:-
[Nyatakan dengan ringkas:-]

(i) Huygen's Principle.
[Prinsip Huygen]

(ii) Diffraction.
[Pembelauan.]

(iii) Refraction.
[Pembiasan.]

(iv) Polarization.
[Pengkutuban.]

(40/100)

(c) Figure 4 shows a 2.0 m long vertical pole extends from the bottom of a swimming pool to a point 50.0 cm above the water. Sunlight is incident at angle $\theta = 55°$. What is the length of the shadow of the pole on the level bottom of the pool? Refractive indices of air and water are given as 1.0 and 1.33, respectively.
[Rajah 4 menunjukkan suatu tiang tegak yang berukuran panjang 2.0 m dari bawah kolam renang ke suatu titik 50.0 cm di atas permukaan air. Cahaya matahari menuju pada sudut $\theta = 55°$. Berapakah panjang bayang tiang dari paras bawah kolam? Indek-indek biasan bagi udara dan air diberikan sebagai 1.0 and 1.33, masing-masing.]

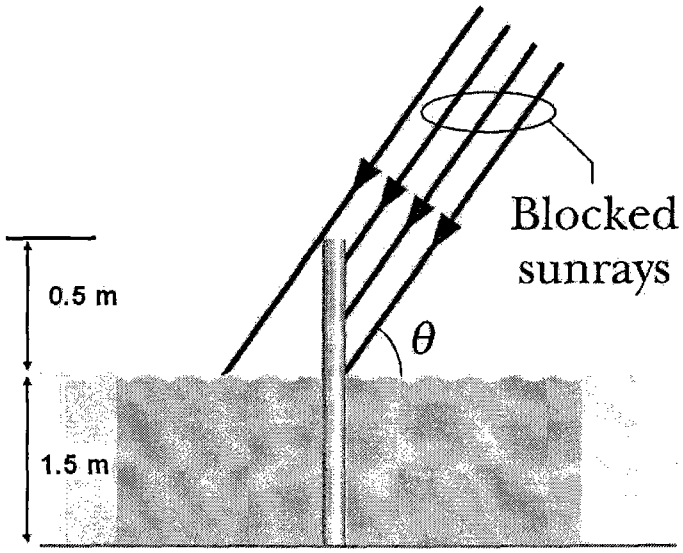

Figure 4 *[Rajah 4]*

(30/100)

5) (a) Schematically draw the Michelson interferometer. Explain clearly how the interference patterns can be formed in this device.
[Lakarkan secara skematik interferometer Michelson. Jelaskan bagaimana corak interferens terbentuk pada alat ini.]

(50/100)

(b) In a double-slit interference experiment, a special light source emits visible light of two wavelengths: $\lambda_1 = 430$ nm and $\lambda_2 = 510$ nm, the separation of the slits d is 0.025 mm, the distance between the slits and the screen L is 1.5 m. Find the separation distance between the third-order bright fringes for these two wavelengths.
[Dalam eksperimen interferens celah-dubel, suatu sumber cahaya khas mengeluarkan cahaya ternampak berjarak gelombang : $\lambda_1 = 430$ nm dan $\lambda_2 = 510$ nm, jarak pemisahan celah d ialah 0.025 mm, jarak di antara celah dan tabir L ialah 1.5 m. Dapatkan jarak pemisahan di antara jalur cerah tertib ketiga bagi kedua-dua jarak gelombang.]

(25/100)

(c) Figure 5 shows a transparent plastic block with a thin wedge of air.
[Rajah 5 menunjukkan blok plastik lutsinar dengan baji udara tipis.]

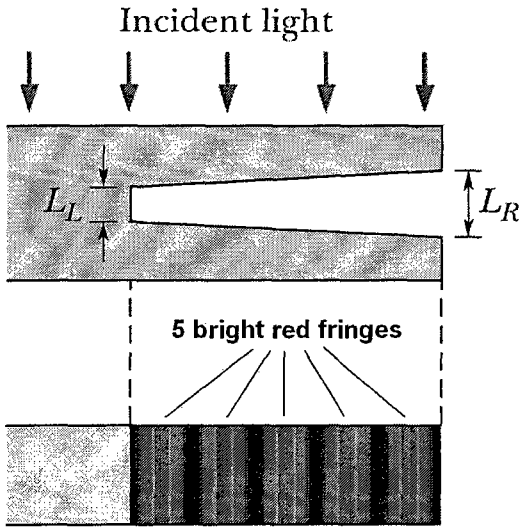

Figure 5 *[Rajah 5]*

Red light with wavelength λ=632 nm is directed downward through the top of the block. Some of the light that passes into the plastic is reflected back up from the top and bottom surfaces of the wedge, which acts as thin film (of air) with thickness that varies from L_L to L_R. An observer looking down on the block sees an interference pattern consisting 6 dark fringes and 5 bright red fringes along the wedge. What is the change in thickness ΔL ($=L_R-L_L$) along the wedge? Refractive index of air is 1.0.
[Cahaya merah berjarak gelombang λ=632 nm ditujukan ke bawah melalui permukaan blok. Sebahagian cahaya yang melalui ke dalam plastik terpantul keatas dari permukaan-permukaan atas dan bawah baji, yang berlakun sebagai filim tipis (bagi udara) dengan ketebalan yang berubah-ubah dari L_L to L_R. Seorang pemerhati melihat ke bawah kearah blok dan melihat corak interferens mengandungi 6 jalur gelap dan 5 jalur-jalur merah cerah sepanjang baji. Berapakah perubahan ketebalan ΔL ($=L_R-L_L$) sepanjang baji? Indek biasan bagi udara ialah 1.0.]

(25/100)