THE OPEN UNIVERSITY OF SRI LANKA
ADVANCED CERTIFICATE IN SCIENCE
PHF2524 - PHYSICS 02 – 2024/2025
FINAL EXAMINATION
DURATION – THREE (03) HOURS

Index No: .....

Date: 15.03.2025 **Time: 1.30 pm to 4.30 pm**

Part – A (MCQ)

- **The question paper (Part A) consists of 25 multiple choice questions.**
- **Indicate your answer for all Multiple-Choice Questions, by underlining the correct option.**
- **At the end of the examination, you should submit the question paper and the answer sheet.**
- **Maximum marks for this part is 50% of the total marks.**

(g = 10 m s^{-2} , c = 3×10^8 m s^{-1})

1. What is the general form of the simple harmonic equation?
   (i) $F = kx$ (ii) $F = kx$ (iii) $a = -\frac{m}{k}x$ (iv) $a = \omega^2 x$ (v) $a = -\omega^2 x$

2. A 0.5 kg object connected to a light spring with a spring constant of 20 N/m oscillates on a friction less horizontal surface. If the amplitude of oscillation, x = 3 cm, what is the total energy of the system?

   (i) 9×10^3 J (ii) 9×10^{-3} J (iii) 9×10^{-2} J (iv) 9×10^2 J (v) 9×10^{-1} J

3. Which of the following waves can travel through a vacuum?

   (i) Sound waves (ii) Electromagnetic (EM) waves (iii) Longitudinal waves
   (iv) Mechanical waves (v) Seismic waves

4. You are sitting on the beach and notice that a seagull floating on the water moves up and down 15 times in 1 minute. What is the frequency of the water waves?

   (i) 4 Hz (ii) 0.4 Hz (iii) 0.04 Hz (iv) 0.25 Hz (v) 0.025 Hz

5. What is the correct expression for the speed of sound in air?
   (i) $v = \sqrt{\frac{\gamma RT}{M^2}}$ (ii) $v = \sqrt{\frac{\gamma RT}{M}}$ (iii) $v = \sqrt{\frac{\gamma RM}{T}}$ (iv) $v = \sqrt{\frac{MRT}{\gamma}}$ (v) $v = \sqrt{\frac{\gamma MT}{R}}$

6. What is the fundamental frequency of a steel wire 1.00 m long with a mass per unit length of 2.00 × 10^{-3} kg/m and under a tension of 80.0 N?

   (i) 1000 kHz (ii) 100 kHz (iii) 1000 Hz (iv) 100 Hz (v) 10 Hz

7. A long tube open at both ends is partially submerged in a beaker of water and a vibrating tuning fork of unknown frequency is placed near the top of the tube. The length of the air column, L, is adjusted by moving the tube vertically. The sound waves generated by the fork are reinforced when the length of the air column corresponds to one of the resonant frequencies of the tube. Suppose the smallest value of L for which a peak occurs in the sound intensity is L_1. The correct expression for the frequency of the tuning fork is,

(i) $\frac{v}{4L_1}$ (ii) $\frac{v}{2L_1}$ (iii) $\frac{v}{L_1}$ (iv) $\frac{2v}{L_1}$ (v) $\frac{4v}{L}$

8. Which of the following is an example of the Doppler effect?
   (i) An echo from a distant mountain
   (ii) A siren changing pitch as an ambulance passes
   (iii) Sound waves traveling through different materials
   (iv) The spreading of waves in water
   (v) None of the above

9. A noisy grinding machine in a factory produces a sound intensity of 1×10^{-5} W/m^2. Given that the threshold of hearing is 1×10^{-12} W/m^2, what is the decibel level of this machine?
   (i) 700 dB (ii) 70 dB (iii) 7 dB (iv) 0.7 dB (v) 0.07 dB

10. A certain piano string is supposed to vibrate at frequency of 440 Hz. To check its frequency, a tuning fork known to vibrate at a frequency of 440 Hz is sounded at the same time the piano key is struck, and a beat frequency of 4 beats per second is heard. What are the two possible frequencies at which the string could be vibrating?

    (i) 436 Hz, 440 Hz (ii) 436 Hz, 444 Hz (iii) 440 Hz, 444 Hz
    (iv) 432 Hz, 436 Hz (v) 436 Hz, 440 Hz

11. What is the definition of a wavefront?

    (i) The path traveled by a wave in a medium
    (ii) A surface over which the wave has a constant frequency
    (iii) A surface joining the points of a wave that have the same phase and amplitude
    (iv) The direction of wave propagation
    (v) The region where wave intensity is maximum

12. Light of wavelength 589 nm in vacuum passes through a piece of glass of index of refraction $n = 1.5$. What is the speed of light inside the glass?

    (i) 1×10^8 m s^{-1} (ii) 2×10^8 m s^{-1} (iii) 2×10^7 m s^{-1}
    (iv) 5×10^7 m s^{-1} (v) 3×10^8 m s^{-1}

13. A light ray of wavelength 589 nm (produced by a sodium lamp) travelling through air is incident on a smooth, flat slab of crown glass at an angle θ_1 of 30° to the normal. At what angle θ_3 does the ray leave the glass as it re-enters the air?

    (i) 20° (ii) 25° (iii) 30° (iv) 45° (v) 60°

14. A fisherman estimates that a fish is 1.5 m below the water surface. What is the actual depth of the fish, if the refractive index if water is 4/3?

(i) 0.5 m (ii) 1 m (iii) 1.5 m (iv) 2 m (v) 3 m

15. According to the Cartesian sign convention for a thin lens, which of the following statements is correct?

(i) Distances measured toward the direction of light are taken as negative.
(ii) Distances measured opposite to the direction of light are taken as positive.
(iii) The thin lens formula after applying sign convention is $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$.
(iv) The focal length of a convex lens is always negative in Cartesian sign convention.
(v) The object distance (u) is always positive, regardless of lens type.

16. If an object is placed 30 cm in front (left) of a converging lens with a focal length of 10 cm, which of the following statements about the image is correct?

(i) The image is virtual, upright, and located 15 cm to the left of the lens.
(ii) The image is real, inverted, and located 15 cm to the right of the lens.
(iii) The image is virtual, inverted, and located 30 cm to the left of the lens.
(iv) The image is real, upright, and located 20 cm to the right of the lens.
(v) The image is real, inverted, and located 30 cm to the right of the lens.

17. A convex lens of focal length 40 cm is in contact with concave lens of focal length 25 cm. What is the power of the combination in diopters?

(i) 3 D (ii) -3 D (iii) +1.5 D (iv) -1.5 D (v) +1 D

18. How is hyperopia (farsightedness) corrected?
(i) Using a diverging (concave) lens.
(ii) Using a converging (convex) lens.
(iii) Using a cylindrical lens.
(iv) Using no lens; it can only be corrected surgically.
(v) Using a bifocal lens.

19. What is the maximum angular magnification of a lens with a focal length of 10.0 cm? Take the least distance of distinct vision (near point of the eye) as 25 cm.

(i) 1.5 (ii) 2.0 (iii) 2.5 (iv) 3 (v) 3.5

20. Which of the following statements is true about an astronomical telescope in normal adjustment?

(i) The final image is real, inverted, and magnified.
(ii) The final image is virtual, erect, and diminished.
(iii) The final image is virtual, inverted, and magnified.
(iv) The final image is real, erect, and diminished.
(v) The final image is real, inverted, and diminished.

21. In a photoelectric effect experiment, light of a certain frequency is incident on a metal surface, causing the emission of electrons. Which of the following changes will increase the kinetic energy of the emitted photoelectrons?

(i) Decreasing the intensity of the incident light.
(ii) Increasing the wavelength of the incident light
(iii) Increasing the frequency of the incident light
(iv) Using a metal with a higher work function
(v) Decreasing the area of the metal surface exposed to light.

22. In a photoelectric experiment, a graph is plotted between the stopping potential (V_s) and the frequency (ν) of the incident light. The resulting graph is a straight line with a slope equal to θ. Which of the following expression represents the value of θ, given that the ϕ is the work function of the surface?

(i) $\frac{h}{e}$ (ii) $\frac{e}{h}$ (iii) $-\frac{\phi}{e}$ (iv) $\frac{eh}{\phi}$ (v) $\frac{2e}{h}$

23. A sodium surface is illuminated with a light of wavelength 300 nm. The work function of sodium is 2.46 eV. If the energy of photon is calculated to be 4.14 eV, what is the maximum kinetic energy of the ejected photoelectrons?
(i) 6.60 (ii) 4.14 eV (iii) 2.46 eV (iv) 1.68 eV (v) none of the above

24. In an X-ray tube, the minimum wavelength of the emitted X-rays depends on,

(i) The current in the filament.
(ii) The atomic number of the target material.
(iii) The accelerating voltage applied to the tube.
(iv) The temperature of the filament.
(v) The density of the target material.

25. Which of the following correctly represents the equation of alpha (α) decay?

(i) ${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$
(ii) ${}^{A}_{Z}X \rightarrow {}^{A+4}_{Z+2}Y + {}^{4}_{2}He$
(iii) ${}^{A}_{Z}X \rightarrow {}^{A-1}_{Z-1}Y + {}^{1}_{1}p$
(iv) ${}^{A}_{Z}X \rightarrow {}^{A}_{Z}Y + {}^{0}_{0}\gamma$
(v) ${}^{A}_{Z}X \rightarrow {}^{A-1}_{Z}Y + {}^{0}_{1}e$

(4×25 = 100 Marks)

Part - B

- **Answer any four (04) questions only.**
- **If more than (04) questions are answered only the first four will be marked.**
- **Each question earns twenty-five (25) marks, amounting to 50% of the total mark.**

1. (A). This section focuses on Simple Harmonic Motion (SHM) and its application to a simple pendulum. Answer the following questions based on the principles of SHM.

   (i) Define "Simple Harmonic Motion (SHM)? **(2 marks)**
   (ii) Write an equation for the period (T), of the oscillations of a simple pendulum in terms of its length (l), and the acceleration due to gravity (g). **(2 marks)**
   (iii) State the conditions under which this equation is valid. **(2 marks)**
   (iv) The bob of a simple pendulum, of length 2.28 m, takes 75 s to complete 25 oscillations. What is the period (T) of oscillation? **(2 marks)**
   (v) Calculate gravitational acceleration (g). (hint $\pi^2 \sim 10$) **(3 marks)**

   (B). Standing waves form in tubes due to the interference between incident and reflected sound waves. The behavior of standing waves differs in open tubes (open at both ends) and closed tubes (closed at one end), primarily due to how sound waves reflect and interact at the boundaries. (neglect the end correction of tube for calculations)

   (i) Draw the standing wave pattern for a closed tube vibrating at its fundamental frequency. **(2 marks)**
   (ii) Derive the expression for the fundamental frequency of a closed tube in terms of its length (l) and velocity of sound (v). **(2 marks)**
   (iii) Draw the standing wave pattern for an open tube vibrating at its fundamental frequency. **(2 marks)**
   (iv) Derive the expression for the fundamental frequency of an open tube in terms of its length (l) and the velocity of sound (v). **(2 marks)**
   (v) A closed organ pipe is 1.24 m long, and the speed of the air in the pipe is 337 m s^{-1}. Calculate the fundamental frequency of this pipe? **(3 marks)**
   (vi) Determine how many harmonics of this closed pipe fall within the normal human hearing range (20 Hz to 20,000 Hz)? **(3 marks)**

2. (A). Sound is a form of energy that travels through a medium (such as air, water, or solids) in the form of longitudinal waves caused by vibrations.
   (i) Briefly explain the following terms.
      (a) Loudness **(2 marks)**
      (b) Pitch **(2 marks)**
      (c) Quality of Sound **(2 marks)**
   (ii) A loudspeaker emits a sound wave with a power output of $P = 4\pi$ W. The sound spreads uniformly in all directions (spherical waves). Calculate the intensity (I) of the sound wave at a distance r =10 m from the loudspeaker. **(2 marks)**
   (iii) Calculate the sound level (L) in decibels (dB) at a distance of r =10 m. ($I_0 = 10^{-12}$W m^{-2}) **(2 marks)**
   (iv) Determine the distance from the loudspeaker at which the intensity drops to 10^{-6} W/m^2? **(2 marks)**
   (v) If the power of the loudspeaker is increased by a factor of 10, how much louder (in dB) is the sound compared to the original power? **(3 marks)**

(B). This section explores the concept of the Doppler Effect, which is a fundamental phenomenon in wave mechanics. Answer the following questions based on these principles.

(i) Define the Dopler Effect? **(2 marks)**

(ii) A bee flies at a constant speed in a straight-line past a microphone, and the frequency of the buzz is detected. Explain the sound pattern detected by microphone as the bee moves towards and away from the microphone. **(2 marks)**

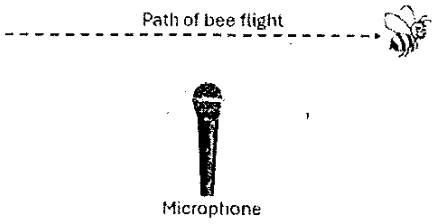

Figure 1

(iii) If the speed of the bee is 8.9 m s^{-1} and the maximum frequency of sound recorded by microphone is 271 Hz, calculate the frequency of sound produced by the bee. Take the speed of sound in air as 340 m s^{-1}. **(3 marks)**

(iv) Determine the minimum frequency recorded by the microphone. **(3 marks)**

3. (A). This section focuses on the principles of lenses and their applications in optical instruments, such as an astronomical telescope. Answer the following questions based on the lens formula and telescope design.

(i) Write down the lens formula with the sign convention. **(3 marks)**

(ii) An astronomical telescope consists of an objective lens with a focal length (f_0) of 80 cm and an eyepiece lens with a focal length (f_e) of 5 cm. Draw a labeled ray diagram of an astronomical telescope in normal adjustment, showing the principal axes, focal points. and the formation of the final image. **(3 marks)**

(iii) Show that the formula for the angular magnification (M) of an astronomical telescope in normal adjustment, is $M = f_0/f_e$. **(2 marks)**

(iv)Calculate the angular magnification of the astronomical telescope given above. **(2 marks)**

(v) Determine the distance between the objective piece and the eyepiece. **(2 marks)**

(B). This section explores common vision defects and their corrections using lenses. Answer the following questions based on the principles of optics and vision.

(i) Explain the following vision defects.

(a) Short-sightedness (myopia) **(2 marks)**

(b) Long-sightedness (hypermetropia) **(2 marks)**

(c) Presbyopia **(2 marks)**

(ii) A person with short-sightedness has a far point of 100 cm and a near point of 20 cm from the eye. What type of lens is required to see distant objects clearly? **(2 marks)**

(iii) Calculate the focal length of the corrective lens? **(2 marks)**

(iv) Determine the new near point when using this corrective lens? **(3 marks)**

4. (A). This section focuses on the principles of refraction and total internal reflection, which are fundamental concepts in geometric optics. Answer the following questions based on these principles.

(i) State the laws of Refraction. **(2 marks)**
(ii) Explain the conditions required for total internal reflection to occur. **(2 marks)**

(iii) A light ray passes from air into a glass block at an angle of incidence of 30°. The refractive index of the glass is 1.52. Calculate the angle of refraction in the glass. **(3 marks)**

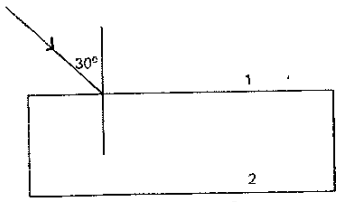

Figure 2

(iv) Calculate the critical angle for light travelling from glass to air. **(3 marks)**
(v) Determine whether total internal reflection occurs at the 2nd surface under the conditions given above. Justify your answer with calculations. **(3 marks)**

(vi) Draw a ray diagram illustrating the path of the light ray as it enters the glass block, refracts, and exits. **(3 marks)**

(B). This section explores the concept of refraction at the air-water interface and its effect on the apparent depth of objects. Answer the following questions based on these principles.

(i) A coin is placed at the bottom of a glass container filled with water to a depth of 12.0 cm. The refractive index of water is 1.33. Draw a ray diagram to illustrate refraction at the air-water interface, clearly showing the real depth and apparent depth of the coin. **(3 marks)**
(ii) State the mathematical relationship between real depth. apparent depth, and refractive index. **(3 marks)**
(iii) Calculate the apparent depth of the coin as seen from directly above the container. **(3 marks)**

5. (A). A star can be approximated as a black body with a surface temperature of 6000 K.

(i) Define the term black body. **(2 marks)**
(ii) Using Wien's Displacement Law, calculate the wavelength at which the star emits maximum radiation. (Wien's constant, $c = 2.9 \times 10^{-3}$ m K) **(3 marks)**
(iii) The total power, P radiated per unit area of the star's surface is given by the Stefan-Boltzmann law, $P = \sigma T^4$ where, $\sigma = 5.67 \times 10^{-8} \text{W m}^{-2}$. Calculate the total power radiated per unit area by the star. **(3 marks)**
(iv) Draw a sketch of black body radiation curves for temperatures of 3000 K, 6000 K, and 9000 K. Clearly label the axes and indicate how the peak wavelength and intensity change with temperature. **(3 marks)**

(B). A monochromatic light of wavelength 450 nm is incident on a metal surface. The work function of the metal is 2.5 eV.
(Planck's constant $h = 6.6 \times 10^{-34}$J Hz^{-1}, speed of light $c = 3 \times 10^{8}$ms^{-1} and 1 eV = 1.602×10^{-19}J)

(i) Define the following terms.
(a) The photoelectric effect. **(2 marks)**
(b) Threshold frequency. **(2 marks)**

(ii) Calculate the energy of the incident photons in electron volts (eV). **(3 marks)**
(iii)Calculate the maximum kinetic energy of the emitted photoelectrons. **(3 marks)**
(iv)Calculate the threshold wavelength for the metal. **(4 marks)**

6. (A). A radioactive substance emits alpha (α), beta (β), and gamma (γ) radiation.

(i) Define the term "radioactive decay". **(2 marks)**
(ii) Compare the properties of alpha, beta, and gamma radiation in terms of: **(6 marks)**
(a) Nature and composition.
(b) Penetrating power.
(c) Ionizing ability.
(d) Behavior in an electric field.

(iii) A sample of a radioactive isotope has an activity of 800 Bq and a half-life of 10 minutes. Write an equation relating the activity A, the initial activity A_0, and the number of half-lives elapsed. **(2 marks)**
(iv)Calculate the decay constant (λ). (ln 2 = 0.6931) **(2 marks)**
(v) Calculate the activity of the sample after 30 minutes. (Let $e^{-2.0796} = 0.125$) **(2 marks)**

(B). The Bohr model of the atom describes the structure of hydrogen and other simple atoms.
(i) Define the following terms
(a) Atomic number. **(2 marks)**
(b) Mass number. **(2 marks)**
(c) Isotope. **(2 marks)**
(ii) The energy levels of hydrogen atom are given by the equation, $E_n = -\frac{13.6}{n^2}$ eV, where n is the principal quantum number. Calculate the energy of an electron in the $n = 2$ energy level. **(2 marks)**
(iii)Determine the wavelength of the photon emitted when the electron transitions from the $n = 3$ level to the $n = 2$ level. **(3 marks)**

Planck's constant $h = 6.6 \times 10^{-34}$ J
1 eV = 1.602×10^{-19} J
Speed of light $c = 3 \times 10^{8}$ m s^{-1}

**********END**********

ප්‍රකෘති සයින (Natural Sines)

	0'	10'	20'	30'	40'	50'	60'
0'	0.0000	0.0029	0.0058	0.0087	0.0116	0.0145	0.0175
1	.0175	.0204	.0233	.0262	.0291	.0320	.0349
2	.0349	.0378	.0407	.0436	.0465	.0494	.0523
3	.0523	.0552	.0581	.0610	.0640	.0669	.0698
4	.0698	.0727	.0756	.0785	.0814	.0843	.0872
5	0.0872	0.0901	0.0929	.0958	0.0987	0.1016	0.1045
6	.1045	.1074	.1103	.1132	.1161	.1190	.1219
7	.1219	.1248	.1276	.1305	.1334	.1363	.1392
8	.1392	.1421	.1449	.1478	.1507	.1536	.1564
9	.1564	.1593	.1622	.1650	.1679	.1708	.1736
10'	0.1736	0.1765	0.1794	0.1822	0.1851	0.1880	0.1908
11	.1908	.1937	.1965	.1994	.2022	.2051	.2079
12	.2079	.2108	.2136	.2164	.2193	.2221	.2250
13	.2250	.2278	.2306	.2334	.2363	.2391	.2419
14	.2419	.2447	.2476	.2504	.2532	.2560	.2588
15	0.2588	0.2616	0.2644	0.2672	0.2700	0.2728	0.2756
16	.2756	.2784	.2812	.2840	.2868	.2896	.2924
17	.2924	.2952	.2979	.3007	.3035	.3062	.3090
18	.3090	.3118	.3145	.3173	.3201	.3228	.3256
19	.3256	.3283	.3311	.3338	.3365	.3393	.3420
20'	0.3420	0.3448	0.3475	0.3502	0.3529	0.3557	0.3584
21	.3584	.3611	.3638	.3665	.3692	.3719	.3746
22	.3746	.3773	.3800	.3827	.3854	.3881	.3907
23	.3907	.3934	.3961	.3987	.4014	.4041	.4067
24	.4067	.4094	.4120	.4147	.4173	.4200	.4226
25	0.4226	0.4253	0.4279	0.4305	0.4331	0.4358	0.4384
26	.4348	.4410	.4436	.4462	.4488	.4514	.4540
27	.4540	.4566	.4592	.4617	.4643	.4669	.4695
28	.4695	.4720	.4746	.4772	.4797	.4823	.4848
29	.4848	.4874	.4899	.4924	.4950	.4975	.5000
30'	0.5000	0.5025	0.5050	0.5075	0.5100	0.5125	0.5150
31	.5150	.5175	.5200	.5225	.5250	.5275	.5299
32	.5299	.5324	.5348	.5373	.5398	.5422	.5446
33	.5446	.5471	.5495	.5519	.5544	.5568	.5592
34	.5592	.5616	.5640	.5664	.5688	.5712	.5736
35	0.5736	0.5760	0.5783	0.5807	0.5831	0.5854	0.5878
36	.5878	.5901	.5925	.5948	.5972	.5995	.6018
37	.6018	.6041	.6065	.6088	.6111	.6134	.6157
38	.6157	.6180	.6202	.6225	.6248	.6271	.6293
39	.6293	.6316	.6338	.6361	.6383	.6406	.6428
40'	0.6428	0.6450	0.6472	0.6494	0.6517	0.6539	0.6561
41	.6561	.6583	.6604	.6626	.6648	.6670	.6691
42	.6691	.6713	.6734	.6756	.6777	.6799	.6820
43	.6820	.6841	.6848	.6884	.6905	.6926	.6947
44	.6947	.6967	.6988	.7009	.7030	.7050	.7071
	60'	50'	40'	30'	20'	10'	0'

මධ්‍ය අන්තරය Mean Differences

	1'	2'	3'	4'	5'	6'	7'	8'	9'
89'	3	6	9	12	15	17	20	23	26
88	3	6	9	12	15	17	20	23	26
87	3	6	9	12	15	17	20	23	26
86	3	6	9	12	15	17	20	23	26
85	3	6	9	12	15	17	20	23	26
84	3	6	9	12	14	17	20	23	26
83	3	6	9	12	14	17	20	23	26
82	3	6	9	12	14	17	20	23	26
81	3	6	9	11	14	17	20	23	26
80'	3	6	9	11	14	17	20	23	26
79	3	6	9	11	14	17	20	23	26
78	3	6	9	11	14	17	20	23	26
77	3	6	9	11	14	17	20	23	26
76	3	6	8	11	14	17	20	23	25
75	3	6	8	11	14	17	20	23	25
74	3	6	8	11	14	17	20	22	25
73	3	6	8	11	14	17	20	22	25
72	3	6	8	11	14	17	19	22	25
71	3	6	8	11	14	17	19	22	25
70'	3	5	8	11	14	16	19	22	25
69	3	5	8	11	14	16	19	22	25
68	3	5	8	11	14	16	19	22	24
67	3	5	8	11	13	16	19	21	24
66	3	5	8	11	13	16	19	21	24
65	3	5	8	11	13	16	19	21	24
64	3	5	8	10	13	16	18	21	24
63	3	5	8	10	13	16	18	21	23
62	3	5	8	10	13	15	18	21	23
61	3	5	8	10	13	15	18	20	23
60'	3	5	8	10	13	15	18	20	23
59	3	5	8	10	13	15	18	20	23
58	2	5	7	10	12	15	17	20	22
57	2	5	7	10	12	15	17	20	22
56	2	5	7	10	12	15	17	19	22
55	2	5	7	10	12	14	17	19	22
54	2	5	7	9	12	14	17	19	21
53	2	5	7	9	12	14	16	19	21
52	2	5	7	9	12	14	16	18	21
51	2	5	7	9	11	14	16	18	20
50'	2	4	7	9	11	13	16	18	20
49	2	4	7	9	11	13	15	18	20
48	2	4	7	9	11	13	15	17	20
47	2	4	6	9	11	13	15	17	19
46	2	4	6	8	11	13	15	17	19
45	2	4	6	8	10	12	15	17	19
	1'	2'	3'	4'	5'	6'	7'	8'	9'

ප්‍රකෘති කෝසයින (Natural Cosines)