Pre-PSPM
SP015
Physics 1

Semester 1
Session 2023/2024
2 hours

NAME			
CLASS		MATRIC NO.	

INSTRUCTIONS TO CANDIDATE:

1. This question paper consists of **8** questions.
2. Answer **ALL** questions.
3. The use of non-programmable scientific calculator is permitted.

Question No.	Full Marks	Marks Obtained
1	2	
2	10	
3	13	
4	8	
5	5	
6	23	
7	8	
8	11	
TOTAL	80	

LIST OF SELECTED CONSTANT VALUES

Speed of light in vacuum	c	$= 3.00 \times 10^{8}\ \text{m s}^{-1}$
Permeability of free space	μ_0	$= 4\pi \times 10^{-7}\ \text{H m}^{-1}$
Permittivity of free space	ε_0	$= 8.85 \times 10^{-12}\ \text{F m}^{-1}$
Electron charge magnitude	e	$= 1.60 \times 10^{-19}\ \text{C}$
Planck constant	h	$= 6.63 \times 10^{-34}\ \text{J s}$
Electron mass	m_e	$= 9.11 \times 10^{-31}\ \text{kg}$ $= 5.49 \times 10^{-4}\ \text{u}$
Neutron mass	m_n	$= 1.674 \times 10^{-27}\ \text{kg}$ $= 1.008665\ \text{u}$
Proton mass	m_p	$= 1.672 \times 10^{-27}\ \text{kg}$ $= 1.007277\ \text{u}$
Hydrogen mass	m_H	$= 1.673 \times 10^{-27}\ \text{kg}$ $= 1.007825\ \text{u}$
Deuteron mass	m_d	$= 3.34 \times 10^{-27}\ \text{kg}$ $= 2.014102\ \text{u}$
Molar gas constant	R	$= 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
Avogadro constant	N_A	$= 6.02 \times 10^{23}\ \text{mol}^{-1}$
Boltzmann constant	k	$= 1.38 \times 10^{-23}\ \text{J K}^{-1}$
Free–fall acceleration	g	$= 9.81\ \text{m s}^{-2}$
Atomic mass unit	1 u	$= 1.66 \times 10^{-27}\ \text{kg}$ $= 931.5\ \dfrac{\text{M}e\text{V}}{c^2}$
Electron volt	1 eV	$= 1.6 \times 10^{-19}\ \text{J}$
Constant of proportionality for Coulomb's law	$k = \dfrac{1}{4\pi\varepsilon_0}$	$= 9.0 \times 10^{9}\ \text{N m}^{2}\ \text{C}^{-2}$
Atmospheric pressure	1 atm	$= 1.013 \times 10^{5}\ \text{Pa}$
Density of water	ρ_w	$= 1000\ \text{kg m}^{-3}$

LIST OF SELECTED FORMULAE SP015

1. $v = u + at$
2. $s = ut + \frac{1}{2}at^2$
3. $v^2 = u^2 + 2as$
4. $s = \frac{1}{2}(u + v)t$
5. $p = mv$
6. $J = F\Delta t$
7. $J = \Delta p = mv - mu$
8. $f = \mu N$
9. $W = \vec{F} \cdot \vec{s} = Fs\cos\theta$
10. $K = \frac{1}{2}mv^2$
11. $U = mgh$
12. $U_s = \frac{1}{2}kx^2 = \frac{1}{2}Fx$
13. $W = \Delta K$
14. $P_{av} = \frac{\Delta W}{\Delta t}$
15. $P = \vec{F} \cdot \vec{v} = Fv\cos\theta$
16. $a_c = \frac{v^2}{r} = r\omega^2 = v\omega$
17. $F_c = \frac{mv^2}{r} = mr\omega^2 = mv\omega$
18. $s = r\theta$
19. $v = r\omega$
20. $a_t = r\alpha$
21. $\omega = \omega_0 + \alpha t$
22. $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$
23. $\theta = \frac{1}{2}(\omega_0 + \omega)t$
24. $\omega^2 = \omega_0^2 + 2\alpha\theta$
25. $\tau = rF\sin\theta$
26. $I = \sum mr^2$
27. $I_{\text{solid sphere}} = \frac{2}{5}MR^2$
28. $I_{\text{solid cylinder/disc}} = \frac{1}{2}MR^2$
29. $I_{\text{ring}} = MR^2$
30. $I_{\text{rod}} = \frac{1}{12}ML^2$
31. $\sum \tau = I\alpha$
32. $L = I\omega$
33. $y = A\sin\omega t$
34. $v = \omega A\cos\omega t = \pm\omega\sqrt{A^2 - y^2}$
35. $a = -\omega^2 A\sin\omega t = -\omega^2 y$
36. $K = \frac{1}{2}m\omega^2\left(A^2 - y^2\right)$
37. $U = \frac{1}{2}m\omega^2 y^2$
38. $E = \frac{1}{2}m\omega^2 A^2$
39. $\omega = \frac{2\pi}{T} = 2\pi f$
40. $T = 2\pi\sqrt{\frac{\ell}{g}}$
41. $T = 2\pi\sqrt{\frac{m}{k}}$

42. $k = \dfrac{2\pi}{\lambda}$

43. $v = f\lambda$

44. $y(x,t) = A\sin(\omega t \pm kx)$

45. $v_{\mathrm{y}} = A\omega\cos(\omega t \pm kx)$

46. $y = 2A\cos kx \sin \omega t$

47. $f_{\mathrm{n}} = \dfrac{nv}{2L}$

48. $f_{\mathrm{n}} = \dfrac{n}{2L}\sqrt{\dfrac{T}{\mu}}$

49. $f_{\mathrm{n}} = \dfrac{nv}{4L}$

50. $v = \sqrt{\dfrac{T}{\mu}}$

51. $\mu = \dfrac{m}{L}$

52. $f_{\mathrm{a}} = \left(\dfrac{v \pm v_{\mathrm{o}}}{v \mp v_{\mathrm{s}}}\right) f$

53. $\sigma = \dfrac{F}{A}$

54. $\varepsilon = \dfrac{\Delta L}{L_0}$

55. $Y = \dfrac{\sigma}{\varepsilon}$

56. $U = \dfrac{1}{2}F\Delta L$

57. $\dfrac{U}{V} = \dfrac{1}{2}\sigma\varepsilon$

58. $\dfrac{Q}{t} = -kA\left(\dfrac{\Delta T}{L}\right)$

59. $\Delta L = \alpha L_0 \Delta T$

60. $\Delta A = \beta A_0 \Delta T$

61. $\Delta V = \gamma V_0 \Delta T$

62. $\beta = 2\alpha$

63. $\gamma = 3\alpha$

64. $n = \dfrac{m}{M} = \dfrac{N}{N_{\mathrm{A}}}$

65. $v_{\mathrm{rms}} = \sqrt{\langle v^2 \rangle}$

66. $v_{\mathrm{rms}} = \sqrt{\dfrac{3kT}{m}} = \sqrt{\dfrac{3RT}{M}}$

67. $PV = \dfrac{1}{3}Nmv_{\mathrm{rms}}^2$

68. $P = \dfrac{1}{3}\rho v_{\mathrm{rms}}^2$

69. $K_{\mathrm{tr}} = \dfrac{3}{2}\left(\dfrac{R}{N_{\mathrm{A}}}\right)T = \dfrac{3}{2}kT$

70. $U = \dfrac{1}{2}fNkT = \dfrac{1}{2}fnRT$

71. $\Delta U = Q - W$

72. $W = nRT\ln\dfrac{V_{\mathrm{f}}}{V_{\mathrm{i}}} = nRT\ln\dfrac{P_{\mathrm{i}}}{P_{\mathrm{f}}}$

73. $W = \int P\,dV = P(V_{\mathrm{f}} - V_{\mathrm{i}})$

74. $W = \int P\,dV = 0$

1. The period of simple pendulum is given by the equation,

$$T = 2\pi\sqrt{\frac{l}{g}}$$

where l is the length of the pendulum and g is the acceleration due to gravity. Show that this equation is dimensionally correct.

[2 marks]

2.

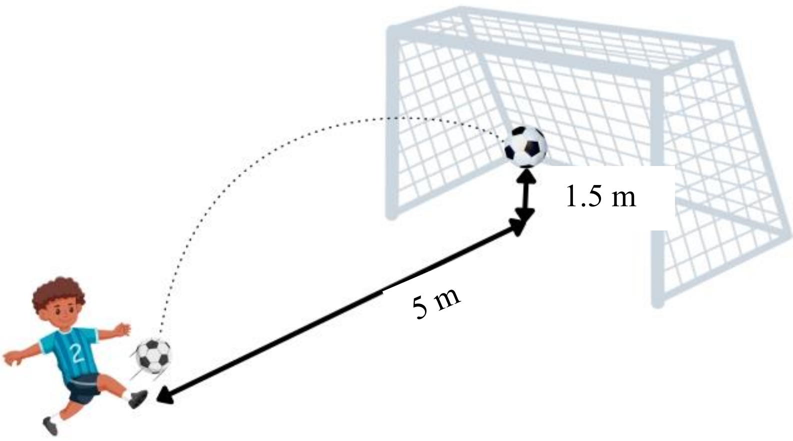
a) A car with an initial velocity of 20 ms^{-1} is moving along a straight road. It accelerates uniformly at a rate of 4 ms^{-2} until it reaches a final velocity of 30 ms^{-1}. The car then slows down until it comes to a complete stop in the next 50 metre and remains stationary for 5 seconds.

(i) Sketch a labelled velocity-time graph for the whole journey.

(ii) Determine the total distance travelled by the car.

[5 marks]

b)



A football player takes a penalty kick, launching the ball into projectile motion. The final vertical displacement of the ball is 1.5 meters above the ground, and the horizontal displacement is 5 meters. It takes 0.5 seconds for the ball to reach the goal post. Determine the magnitude of

(i) the initial velocity of the ball being kicked.

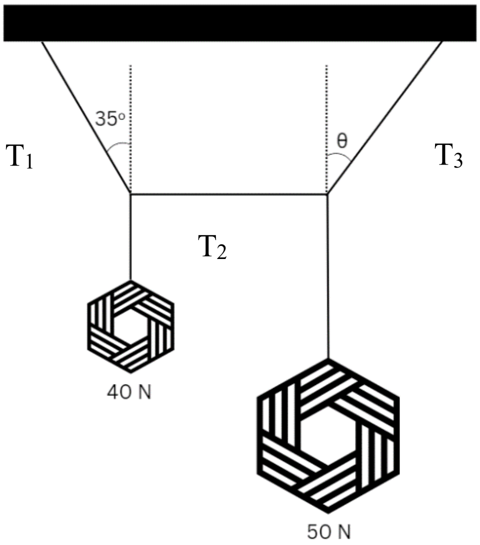
(ii) the final speed of the ball when it reaches the goal post.

[5 marks]

3.

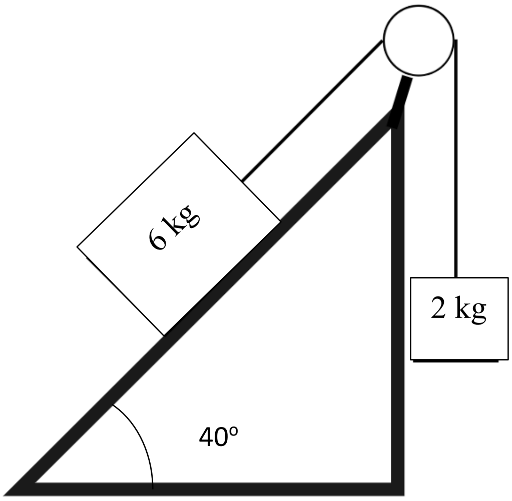
a) Two identical balls where ball A is initially moving to the right with a velocity of 25 ms^{-1} collides with ball B that is initially at rest. Determine the final velocity of ball A if the velocity of ball B is 10 ms^{-1} at 30° from the horizontal after the collision.

[3 marks]



b) FIGURE shows two hanging deco of weight 40 N and 50 N respectively. Determine T_1, T_2, T_3 and θ as the system is in equilibrium.

[5 marks]



c) FIGURE shows two boxes connected by a frictionless pulley. The 6 kg box is released from rest and slides down the rough inclined plane with the coefficient of kinetic friction of 0.15. Determine

(i) The acceleration for both boxes.

(ii) The tension of the string.

[5 marks]

4.

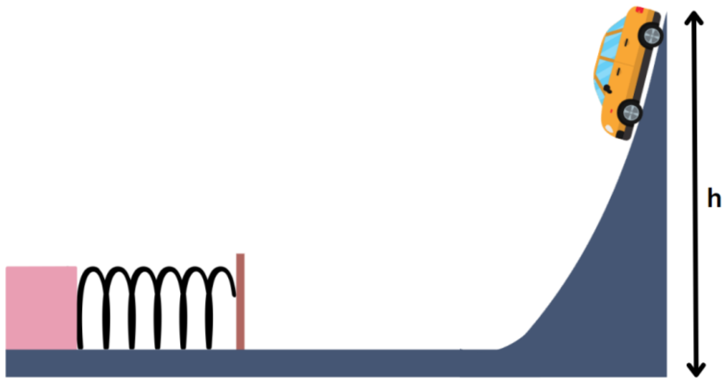


FIGURE shows a model car of mass 5 kg slides down a frictionless ramp into a spring. The spring has a spring constant of 4000 Nm^{-1} and experiences a maximum compression of 23 cm. Determine

(i) The height of the initial release point, h.

(ii) The speed of the model car when the spring has been compressed for 15 cm.

(iii) The average power delivered to the model car if the time taken to compress the spring by 15 cm is 50 ms.

[8 marks]

5. A conical pendulum is formed by attaching a 0.2 kg ball to a 50 cm long string. It is then allowing the ball to move in horizontal circular motion with the string making an angle of 30^o to the vertical. Determine

(i) The centripetal acceleration of the ball.

(ii) The period of revolution.

[5 marks]

6.

a) A mass-spring system undergoes simple harmonic motion with an amplitude of 5 cm and a frequency of 2 Hz.

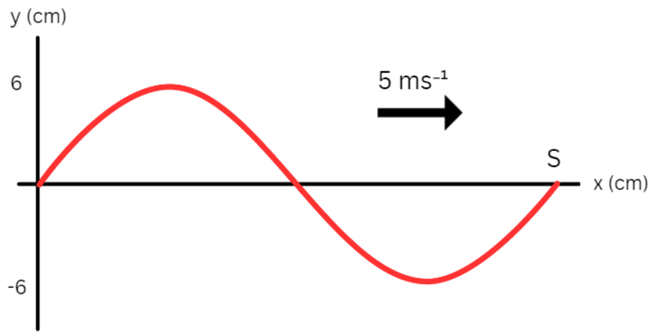
(i) Write the expression for its velocity as a function of time.

(ii) Determine the acceleration of the mass-spring system at $t = 15\ s$.

(iii) If the mass attached to the spring is then doubled, determine the value of new period in terms of the old one.

[5 marks]

b) The displacement-distance graph of a wave travelling with a velocity of 5 ms^{-1} is shown as in FIGURE below.



The time taken for a point in the wave to complete one cycle is 0.5 seconds.

(i) Determine the value of S in the graph.
(ii) Express the equation of the wave.
(iii)Determine the particle vibrational velocity when displaced vertically 3.5 cm from equilibrium position.

[5 marks]

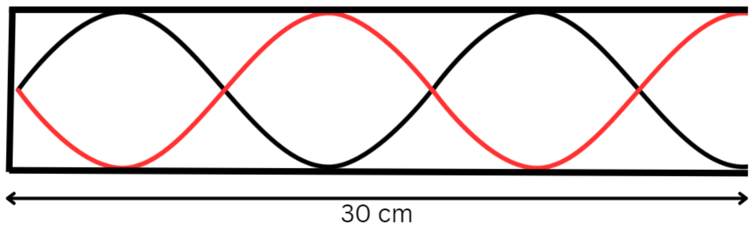
c) A standing wave is given by the equation,

$$y = 8\cos 5\pi x \ \sin\frac{\pi}{2}t$$

where y and x are in cm and t is in s. Determine
(i) amplitude of a particle at $x = 1.2\ cm$
(ii) speed of the wave

[4 marks]

d) A tube 30 cm long with one end closed produces a standing wave as in FIGURE.

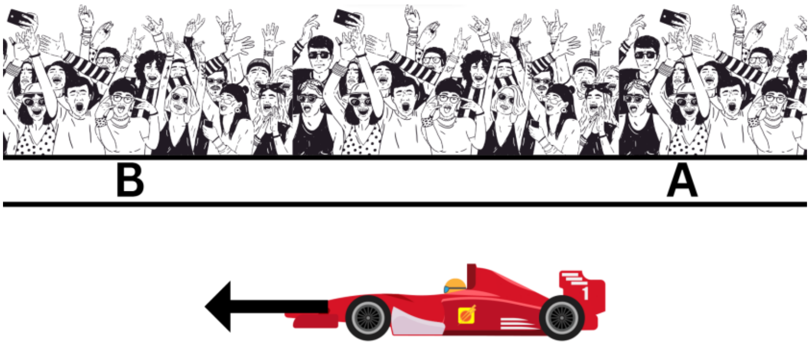


Determine

(i) the wavelength of the wave.
(ii) the number of harmonic if the frequency produced above is 2100 Hz.

(Given speed of sound in air = 343 ms^{-1})

[4 marks]

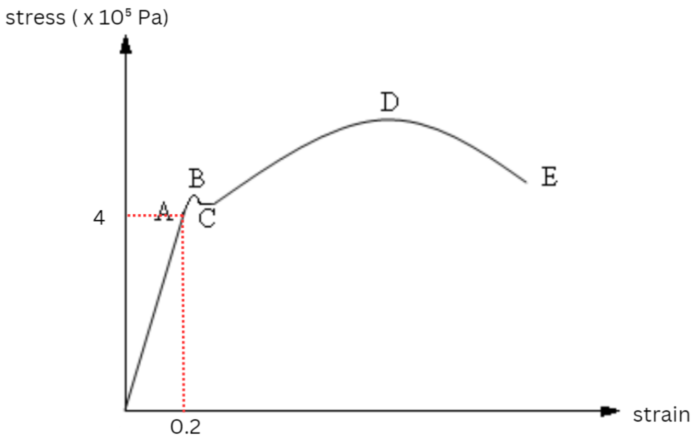


e) F1 car is moving on a straight track at a constant speed of 322 km per hour emits a predominant frequency of 750 Hz. Two spectators, A and B, are standing along the track at different distances as in FIGURE. As the F1 car moves toward spectator B and simultaneously moves away from spectator A, find the ratio of the apparent frequency heard by spectator B to the apparent frequency heard by spectator A. Given the speed of sound in air is 343 ms^{-1}.

[5 marks]

7.

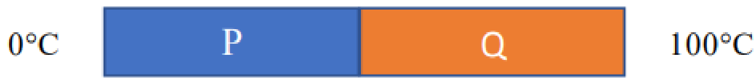
a) FIGURE shows the graph of stress-strain for a metal under tension.



Determine,

(i) strain energy per unit volume of the metal.
(ii) point where marked the change in internal structure of the metal.

[2 marks]



b) FIGURE shows two properly insulated rods, P and Q, that area of the same size but of different material make thermal contact. The free ends of P and Q are maintained at temperatures 0°C and 100°C respectively. The thermal conductivity of P is 20% from the thermal conductivity of Q.
   (i) Determine the temperature at the junction between P and Q under steady condition.
   (ii) Sketch the graphs to show the variation in temperature across the distance P and Q.

[4 marks]

c) Determine the change in area (in cm^2) of a 60.0 cm by 150 cm car windshield when the temperature changes from 0 °C to 36 °C. (The coefficient of linear expansion of glass is 9×10^{-6} °C^{-1}).

[2 marks]

8.

a) A container contains 83.75 g m^{-3} hydrogen gas is at temperature of 550 K. Molar mass of hydrogen is 2.02 g mol^{-1}. Determine
   (i) the r.m.s speed of the hydrogen gas
   (ii) the pressure of the hydrogen gas
   (iii)the average translational kinetic energy for one molecule of hydrogen gas.

[5 marks]

b) Two moles of an ideal gas in a container have a pressure of 1.2×10^5 N m^{-2} at 50 °C. The gas undergoes isothermal compression until its volume becomes a quarter of its original volume. The gas is then undergoing isochoric process and return to its original pressure. Determine
   (i) The pressure of the gas after the process of isothermal compression.
   (ii) The total work done on the gas.
   (iii)Sketch and label the graph of pressure against volume to show the process undergoes by the gas.

[6 marks]

END OF QUESTION PAPER