KOLEJ MATRIKULASI SELANGOR

PHYSICS SP015

SESSION 2023/2024

PRE PSPM I

2 hours

Name:

Matric no:

Class:

INSTRUCTION TO CANDIDATE:

This question paper contains 8 questions.

Answer all the questions.

NO.	MARKS	
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	$= 3.00 \times 10^{8}$ m s^{-1}
Permeability of free space	μ_o	$= 4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_o	$= 8.85 \times 10^{-12}$ F m^{-1}
Electron charge magnitude	e	$= 1.60 \times 10^{-19}$ C
Planck constant	h	$= 6.63 \times 10^{-34}$ J s
Electron mass	m_e	$= 9.11 \times 10^{-31}$ kg $= 5.49 \times 10^{-4}$ u
Neutron mass	m_n	$= 1.674 \times 10^{-27}$ kg $= 1.008665$ u
Proton mass	m_p	$= 1.672 \times 10^{-27}$ kg $= 1.007277$ u
Hydrogen mass	m_H	$= 1.673 \times 10^{-27}$ kg $= 1.007825$ u
Deuteron mass	$\mathbf{m_d}$	$= 3.34 \times 10^{-27}$ kg $= 2.014102$ u
Molar gas constant	R	$= 8.31$ J K^{-1} mol^{-1}
Avogadro constant	N_A	$= 6.02 \times 10^{23}$ mol^{-1}
Boltzmann constant	k	$= 1.38 \times 10^{-23}$ J K^{-1}
Free-fall acceleration	g	$= 9.81$ m s^{-2}
Atomic mass unit	$1\ u$	$= 1.66 \times 10^{-27}$ kg $= 931.5\ \frac{MeV}{c^2}$
Electron volt	$1\ eV$	$= 1.6 \times 10^{-19}$ J
Constant of proportionality for Coulomb's law	$k = \frac{1}{4\pi\varepsilon_o}$	$= 9.0$ x 10^{9} N m^2 C^{-2}
Atmospheric pressure	$1\ atm$	$= 1.013$ x 10^{5} Pa
Density of water	ρ_w	$= 1000$ kg m^{-3}

LIST OF SELECTED FORMULAE

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. $\omega = \omega_o + \alpha t$
22. $\theta = \omega_o t + \frac{1}{2}\alpha t^2$
23. $\theta = \frac{1}{2}(\omega_o + \omega)t$
24. $\omega^2 = {\omega_o}^2 + 2\alpha\theta$
25. $\tau = rF\sin\theta$
26. $I = \sum mr^2$
27. $I_{solid\ sphere} = \frac{2}{5}MR^2$
28. $I_{solid\ cylinder/disc} = \frac{1}{2}MR^2$
29. $I_{ring} = MR^2$
30. $I_{rod} = \frac{1}{12}ML^2$
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. $K = \frac{1}{2}m\omega^2(A^2 - y^2)$
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. $T = 2\pi\sqrt{\frac{l}{g}}$
41. $T = 2\pi\sqrt{\frac{m}{k}}$
42. $k = \frac{2\pi}{\lambda}$
43. $v = f\lambda$
44. $y(x,t) = A\sin(\omega t \pm kx)$
45. $v_y = A\omega\cos(\omega t \pm kx)$
46. $y = 2A\cos kx\sin\omega t$

47. $f_n = \frac{nv}{2L}$

48. $f_n = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$

49. $f_n = \frac{nv}{4L}$

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

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

52. $f_a = \left(\frac{v \pm v_o}{v \mp v_s}\right) f$

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

54. $\varepsilon = \frac{\Delta L}{L_o}$

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

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

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

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

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

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

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

62. $\beta = 2\alpha$

63. $\gamma = 3\alpha$

64. $n = \frac{m}{M} = \frac{N}{N_A}$

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

66. $v_{rms} = \sqrt{\frac{\overline{3kT}}{m}} = \sqrt{\frac{\overline{3RT}}{M}}$

67. $PV = \frac{1}{3} N m {v_{rms}}^2$

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

69. $K_{tr} = \frac{3}{2}\left(\frac{R}{N_A}\right)T = \frac{3}{2}kT$

70. $U = \frac{1}{2} f N k T = \frac{1}{2} f n R T$

71. $\Delta U = Q - W$

72. $W = nRT \ln\frac{v_f}{v_i} = nRT \ln\frac{P_i}{P_f}$

73. $W = \int P dV = P\left(V_f - V_i\right)$

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

1. Show that the expression $\boldsymbol{A = \pi r^2}$ is homogenous.

[2 *marks*]

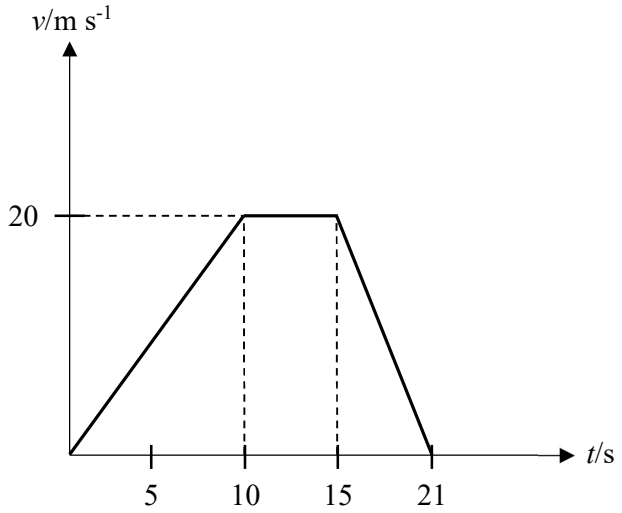
2. (a) A jet lands on an aircraft carrier at a speed of 63 m s^{-1}.

i. What is its acceleration if it stops in 2.0 s due to an arresting cable that snags the airplane and brings it to a stop?

ii. If the plane touches down at front of the aircraft carrier (assume initial position when landing s = 0 m), what is the final position of the plane?

[2 *marks*]

(b)



Graph above shows the part of a performance data from a BMW 745i car owned by a proud physics student.

i. Calculate from the graph the total distance travelled.

ii. Sketch a labelled graph of acceleration versus time between t = 0 s and t = 21 s.

[4 *marks*]

(c) Mike Powell, a long jumper, leaves the ground at an angle of 20.0° above the horizontal and at a speed of 11.0 m s^{-1}.

i. How far does he jump in the horizontal direction?

ii. What is the maximum height reached?

[4 *marks*]

3. (a) A ball of mass 3.5 kg is dropped onto a horizontal plate as shown in **FIGURE 1**.

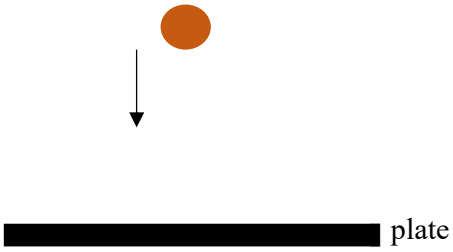


FIGURE 1

Just as the ball reaches the plate, the ball has a speed of 4.5 m s^{-1}. It bounces from the plate so that its speed, immediately after losing contact with the plate, is 3.5 m s^{-1}. The ball is in contact with the plate for 0.14 s. Calculate, for the time that the ball is in contact with the plate,

i. the nett force acting on the ball, and

ii. the loss in kinetic energy of the ball.

[6 *marks*]

(b)

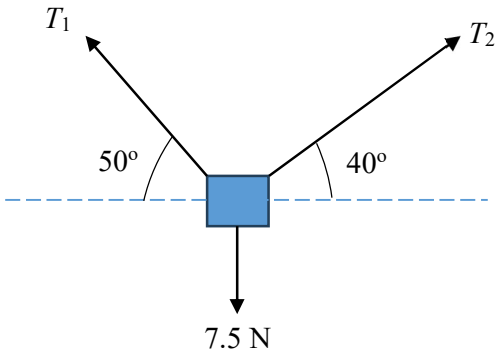


FIGURE 2

FIGURE 2 shows a system is in equilibrium. Sketch free-body diagram and calculate the magnitude of T_1 and T_2.

[7 *marks*]

4. (a)

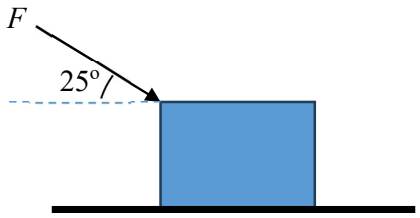


FIGURE 3

FIGURE 3 shows a force of 20 N pushing a 3 kg box and displacing it by 3.0 m across a rough horizontal surface. If the frictional force is 2 N, calculate the total work done.

[2 *marks*]

(b)

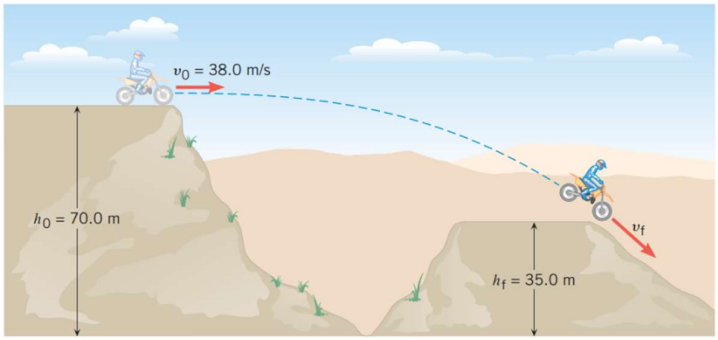


FIGURE 4

A daredevil is trying to leap across the canyon shown in **FIGURE 4** by driving horizontally off the cliff at a speed of 38 m s^{-1}. By ignoring air resistance, find the speed with which the cycle strikes the ground on the other side.

[4 *marks*]

(c) Calculate the power output of a 1.1 g spider crawling down a wall at rate of 2.5 cm s^{-1}.

[2 *marks*]

5.

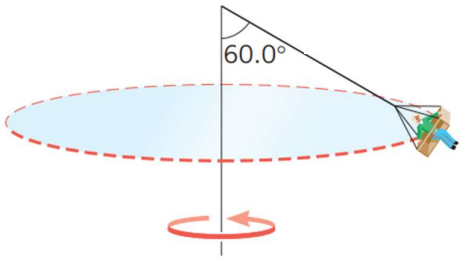


FIGURE 5

A "swing" ride at a carnival consists of chairs that are swung in a circle by 15.0 m cables attached to a vertical rotating pole, as in **FIGURE 5**. Suppose the total mass of a chair and its occupant is 179 kg.

(a) Determine the tension in the cable attached to the chair.

(b) Find the speed of the chair.

[5 *marks*]

6. (a) A 200 g mass vibrates horizontally without friction at the end of a horizontal spring for $k = 7.0$ N m^{-1}. The mass is displaced 5.0 cm from equilibrium and released. Find

i. its maximum speed

ii. its speed and acceleration when it is 3.0 cm from equilibrium

iii. its maximum kinetic energy

[7 *marks*]

(b) Write an equation representing a wave moving in the negative x-axis direction, having an amplitude of 0.5 m, frequency of 500 Hz, and a speed of 300 m s^{-1}.

[5 *marks*]

(c) When a boy plucked a guitar, the string vibrates with a velocity of 500 m s^{-1} to a tension of 850 N, it produces a fundamental frequency of 440 Hz. Find the mass and the length of the string.

[3 *marks*]

(d) The length of a closed pipe is 18.0 cm. If the speed of sound in air is 330 m s^{-1}.

i. Draw the wave pattern for fundamental mode and first overtone when one blows across the opened end of the pipe.

ii. What are the two lowest frequencies been produced?

[5 *marks*]

(e) A car is travelling in a straight line at 30 m s^{-1} approaches a stationary source which emits sound of frequency 5000 Hz. If the speed of sound is 330 m s^{-1}, calculate apparent frequency received by the car.

[3 *marks*]

7. (a) A wire of cross-sectional area 0.52 mm^2 and natural length 60.0 cm is stretched at both ends by a force of 50 N as shown in the **FIGURE 6.**

FIGURE 6

i. What is the stress on the wire?

ii. If the extension is 0.12 cm, what is the strain?

iii. Calculate the Young's modulus.

iv. What is the strain energy of the stretched wire?

[4 *marks*]

(b) A water tank with a square base of sides 2 m and height 1.5 m is filled with a liquid at 87 °C. The wall of the tank is 10 mm thick. If the temperature outside the tank is 28 °C, calculate the rate of heat loss due to conductivity through the base of the tank.
[Thermal conductivity of tank = 3.78×10^{-2}W m^{-1}K^{-1}]

[2 *marks*]

(c)

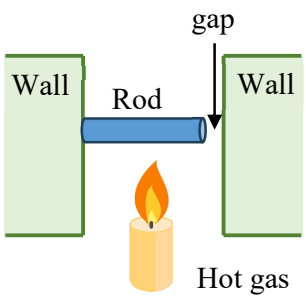


FIGURE 7

A 15 cm long steel rod is fixed to a brick wall. There is a gap between the end of the rod and the opposite wall as shown in **FIGURE 7**. At 33 °C, the width of the gap is 0.8 mm. If the expansion of the wall is negligible, calculate the temperature of the hot gas when the end of the rod touches the wall.
[Coefficient of linear expansion of steel = 1.6×10^{-5} K^{-1}]

[2 *marks*]

8. (a) The temperature of two samples of the same gas are 86 °C and 25 °C respectively. What is the ratio of the root mean square speeds of the gas molecules in the two samples?
[0 °C = 273.15 K]

[3 *marks*]

(b) A vessel with a volume of 0.95 m^3 contains 1.3 moles of helium gas at 3 °C. If the helium gas acts as an ideal gas, determine

i. the total translational kinetic energy of the molecules of the gas.

ii. the average molecular kinetic energy.
[0 °C = 273.15 K]

[2 *marks*]

(c)

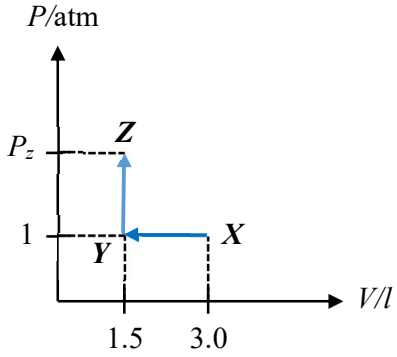


FIGURE 8

The *P*-*V* graph in **FIGURE 8** shows an ideal gas compressed from 3.0 litres to 1.5 litres at a constant pressure of 1.0 atm. The system is then supplied with heat at a constant volume, while the pressure and temperature are allowed to fluctuate until the system reaches the initial temperature at *X*. Calculate the

i. total work done in the above process,

ii. value of final pressure in atm.

[6 *marks*]