HCMC UNIVERSITY OF TECHNOLOGY AND EDUCATION
Faculty of Applied Sciences

FINAL EXAMINATION
SEMESTER 1 – ACADEMIC YEAR 2020-2021
Course name: **Principles of Physics 1**
Course ID: PHYS130902
Exam code: 01; Number of pages: 03;
Duration: 90 minutes.

Note: + Proctors are not allowed to give any unauthorised explanation.
+ Students are allowed to use one A4 paper sheet as a memory aid.

Question 1: (0.5 marks/10)
A particle moves according to the law $x = A\sin \pi t$, where x is the displacement and t is time. Find the distance be traversed by the particle in 3.0 s.

Question 2: (1.5 marks/10)

A thin cylindrical wheel of radius r = 40 cm is allowed to spin on frictionless axle. The wheel, which initially at rest, has a tangential force applied at right angles to its radius of magnitude 50 N as shown in Fig. 1a. The wheel has a moment of inertia equal to 20 kg m^2. Calculate

a) The torque applied to the wheel

b) The angular acceleration of the wheel

c) The angular velocity of the wheel after 3 s

d) The total angle swept out in this time

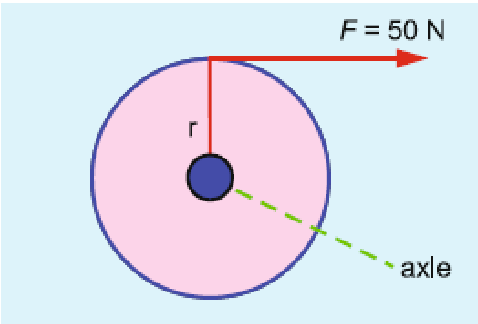


Fig. 1

Question 3: (1.0 marks/10)

A ski jumper leaves the ski track moving in the horizontal direction with a speed of ***v*** m/s (Fig. 2). The landing incline below his falls off with a slope of Φ. Where does he land on the incline?

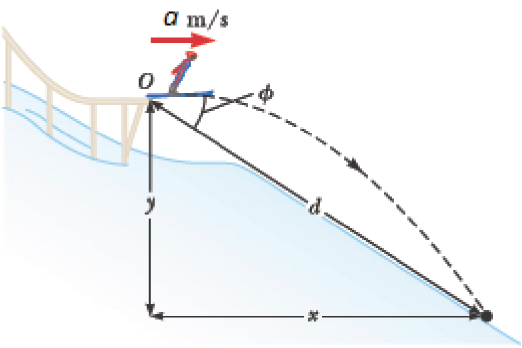


Fig. 2

Question 4: (1.0 marks/10)

When the metal ring and metal sphere in Fig. 3 are both at room temperature, the sphere can barely be passed through the ring.

a) After the sphere is warmed in a flame, it cannot be passed through the ring. Explain.

b) What if? What if the ring is warmed and the sphere is left at room temperature? Does the sphere pass through the ring?

Fig. 3

Question 5: (2.0 marks/10)

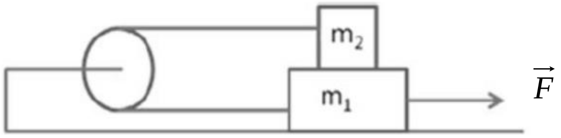
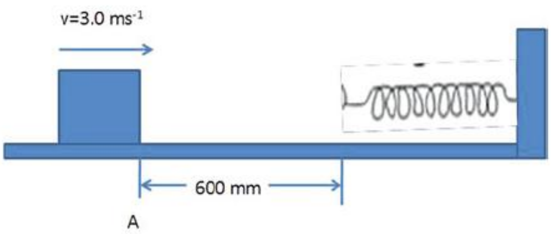


Fig. 4

Two blocks with masses m_1 and m_2 are attached by an unstretchable string around a frictionless pulley of radius r and moment of inertia I (Fig. 4). Assume that there is no slipping of the string over the pulley and that the coefficient of kinetic friction between the two blocks and between the lower one and the floor is identical. If a horizontal force F is applied to m_1, calculate the acceleration of m_1.

Question 6: (2.0 marks/10)



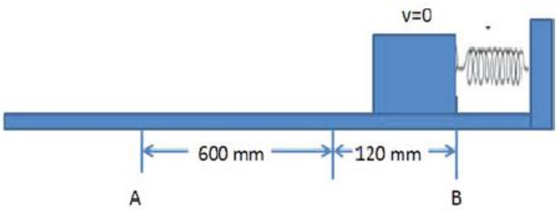


Fig. 5a **Fig. 5b**

A spring is used to stop a crate of mass 50 kg which is sliding on a horizontal surface. The spring has a spring constant k = 20 kN/m and is initially in its equilibrium state. In position A shown in the Fig. 5a (left-hand side) the crate has a velocity of 3.0 m/s. The compression of the spring when the crate is instantaneously at rest (position B in the Fig. 5b – right-hand side) is 120 mm.

a) What is the work done by the spring as the crate is brought to a stop?

b) Write an expression for the work done by friction during the stopping of the crate (in terms of the coefficient of kinetic friction).

c) Determine the coefficient of friction between the crate and the surface.

Question 7: (2.0 marks/10)

The initial values for the volume and pressure of a certain amount of nitrogen gas are V_1 = 0.06 m^3 and p_1 = 10^5 N/m^2, respectively. First, the gas undergoes an isovolumetric process (process 1 – 2), which trips the pressure; then it is followed by an isobaric process (process 2 – 3), which reduces the volume by a factor of three; finally, the volume of the gas is tripled by an isothermal process (process 3 – 4).

a) Given the initial and final temperatures, T_1 and T_4, of the nitrogen gas if the temperature after the first (isovolumetric) process is $T_2 = 1083$ K.

b) Find the volume, V_4, and pressure, p_4, at the final state of the gas, and then sketch the three processes in a p-V diagram.

c) How much heat is gained by nitrogen gas during the first (isovolumetric) process and how much heat is given away by nitrogen gas during the second (isobaric process)? The amount of heat required to raise the temperature of 1 mol of nitrogen by 1K while the gas pressure is kept constant is $c_p = 29.12$ J/(mol K).

d) Find the change in the internal energy of the nitrogen gas by the end of the final process compared to the initial value.

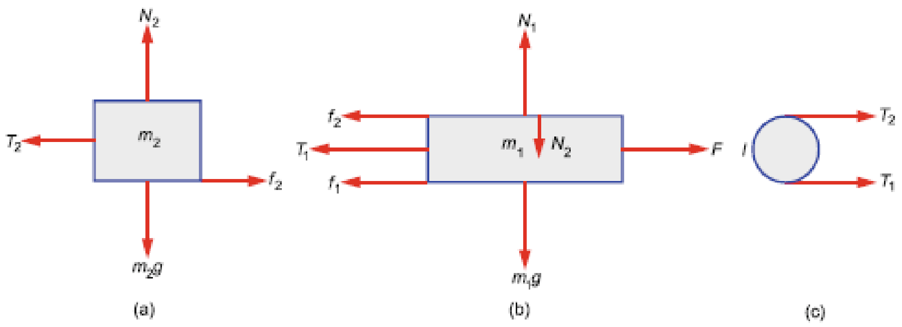
Where $g = 9.80\ m/s^2$; $R = 8.31$ J/mol.K; $C_V = C_P/\gamma$; $\gamma = 1.4$ for diatomic gases

Learning outcome mapping	**Assessed in**
[ELO 1.1]: Understanding various concepts, theorems, and laws related to classical mechanics. [ELO 3.1]: To express the learned knowledge by problem solving capability and answer questions related to the concepts learned.	Questions 1, 2
[ELO 2.1]: Applying the knowledge and skills required to solve the problems in mechanics. [ELO 3.1]: To express the learned knowledge by problem solving capability and answer questions related to the concepts learned.	Questions 3, 5, 6
[ELO 2.1]: Applying the principles of thermodynamics to explain the phenomena related to the temperature as well as solving the related problems. [ELO 3.1]: To express the learned knowledge by problem solving capability and answer questions related to the concepts learned.	Question 4, 7

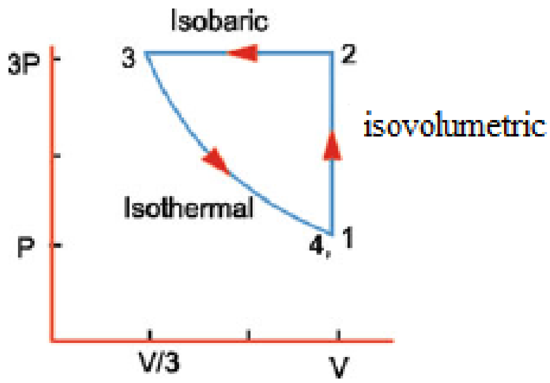
Approved by program chair
(signed and named)

KEYS AND SCORES FOR QUESTIONS
Final Exam of Principles of Physics 1
Edited by:

Question	Answer	Marks
1 (0.5)	$x = A\sin \pi t = A\sin \omega t$ where ω is the angular velocity, ω = π Time period $T = \frac{2\pi}{\omega} = \frac{2\pi}{\pi} = 2s$ In $\frac{1}{2}s$ (a quarter of the cycle) the distance covered is A. Therefore in 3 s the distance covered will be 6A	0.5
2 (1.5)	a) $\boldsymbol{\tau = r \times F}$ $\tau = rF\sin\theta = (0.4\ m)(50\ N)\sin 90^o = 20\ N.m$ b) $\tau = I\alpha$ $\alpha = \frac{\tau}{I} = \frac{20}{20} = 1.0\ rad/s^2$ c) $\omega = \omega_o + \alpha t = 0 + 1 \times 3 = 3\ rad/s$ $\omega^2 = \omega_o^2 + 2\alpha\theta;\quad \theta = \frac{3^2 - 0}{2x1} = 4.5\ rad$ d)	0.25 0.25 0.5 0.5
3(1.0)	The initial velocity components are $v_{xi} = v\ m/s;\ v_{yi} = 0;$ The jumper's x and y coordinates at the landing point are $x_f = d\cos\Phi;\ y_f = -d\sin\Phi$. (1) $x_f = v_{xi}t;$ (2) $y_f = v_{yi}t - (1/2)gt^2;$ (3) $d\cos\Phi = v_{xi}t;$ (4) $-d\sin\Phi = -(1/2)gt^2$. Solve Equ. (3) for *t* and sub. The result into Equ. (4): $-d\ \sin\Phi = -\frac{1}{2}g\left(\frac{d\cos\varphi}{v_{xi}}\right)^2$ Solve for *d*: $d = \frac{2v_{xi}^2\sin\phi}{g\cos^2\phi}$ Thus, *x* and *y* coordinates of the point at which the skier lands $x_f = d\cos\varphi = \left[\frac{2v^2\sin\varphi}{g\cos^2\varphi}\right]\cos\varphi$; $y_f = -d\sin\varphi = \left[\frac{2v^2\sin\varphi}{g\cos^2\varphi}\right]\sin\varphi$.	0.25 0.25 0.25 0.25
4(1.0)	a) The sphere expands when heated, so that it no longer fits through the ring. With the sphere still hot, you can separate the sphere and ring by heating the ring. This more surprising result occurs because the thermal expansion of the ring is not like the inflation of a blood-pressure cuff. Rather, it is like a photographic enlargement; every linear dimension, including the hole diameter, increases by the same factor. The reason for this is that the atoms everywhere, including those around the inner circumference, push away from each other. The only way that the atoms can accommodate the greater distances is for the circumference—and corresponding diameter—to grow. This property was once used to fit	0.5

	metal rims to wooden wagon wheels. If the ring is heated and the sphere left at room temperature, the sphere would pass through the ring with more space to spare b) Heating the ring increases its diameter, the sphere can pass through it easily. The hole in the ring expands as if it were filled with the material of the ring.	0.5
5(2.0)	Free body diagram for twos blocks and the pulley are shown in Fig.  	0.5
	The Equs. Of motion for m_1, m_2 and the pulley are m_1: $m_1a = F - f_1 - f_2 - T_1$; (1) m_2: $m_2a = T_2 - f_2$; (2) Pulley: $r(T_1 - T_2) = \alpha I = \frac{a}{r}I$. (3)	0.5
	Balancing the vertical forces $N_1 = N_2 + m_1g = (m_1 + m_2)g$ $N_2 = m_2g$	0.5
	Frictional forces are $f_1 = \mu N_1 = \mu(m_1 + m_2)g$; (4) $f_2 = \mu N_2 = \mu m_2 g$. (5) Combining (1), (2), (3), (4) and (5), eliminating f_1, f_2 and T $$a = \frac{F - \mu(m_1 + 3m_2)g}{m_1 + m_2 + \frac{I}{r^2}}$$	0.5
6(2.0)	a) Work done by the spring $W_s = \frac{1}{2}kx^2 = \frac{1}{2}\times 20\times 10^3 \times (0.12)^2 = 144\ J$	0.5
	b) Work done by friction $W_f = \frac{1}{2}mv^2 - W_s = \frac{1}{2}\times 50\times 3^2 - 144 = 81\ J$	0.5
	c) $W_f = \mu mgs$	0.5
	$\mu = \frac{W_f}{mgs} = \frac{81}{50\times 9.8\times(0.60+0.12))} = 0.2296$	0.5
7(2.0)	a) and b) - $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$; $T_1 = \frac{P_1V_1}{P_2V_2}T_2 = \frac{P_1V_1}{3P_1V_1}1083 = 361\ K$; - $n = \frac{P_1V_1}{RT_1} = \frac{(10^5)(0.06)}{(8.31)(361)} - 2\cdots mol$;	0.25

	- $\frac{P_3V_3}{T_3}=\frac{P_2V_2}{T_2}$; $T_3=\frac{P_3V_3}{P_2V_2}T_2=\frac{P_2(V_2/3)}{P_2V_2}1083=361\,K$;	0.25
	- $T_4 = T_3 = 361\ K$ (3→4 isothermal process);	0.25
	- $\frac{P_3V_3}{T_3}=\frac{P_4V_4}{T_4}$; $P_4=\frac{V_3T_4}{V_4T_3}P_3=\frac{V_3T_3}{3V_3T_3}P_2=\frac{P_2}{3}=\frac{3P_1}{3}=P_1=10^5\ N/m^2$	0.25
	- $V_4=\frac{nRT_4}{P_4}=\frac{2\times 8.31\times 361}{10^5}=0.06\,m^3$.	
	Thus, the *P*, *V*, *T* coordinates of the initial and final points on the indicator diagram is identical.	
	c) Heat gained by N_2 in the first (isovolumetric) process, Fig. below:	



	- $C_V = C_P/\gamma = 29.12/1.4 = 20.8\ J/(molK)$;	0.25
	- $Q_1 = nC_V\Delta T = 2\times 20.8\times(1083-311) = 32115\ J$;	
	- $W_{12} = 0$ (1→2 isovolumetric); thus, $\Delta E_1 = Q_1 = 32115\ J$	
	- $Q_2 = nC_P\Delta T = 2\times 29.12\times(361-1083) = -42049\ J$	
	- $W_{23} = P\Delta V = P_2(V_3-V_2) = -3\times 10^5\times(2/3)\times 0.06 = -12000\ J$;	0.25
	- Thus, $\Delta E_2 = Q_3 - W_{23} = -42049 - (-12000) = 30049\ J$	
	- $\Delta E_3 = 0$ (3→4 isothermal process)	
	d) Net change in energy	0.5
	- $\Delta E = \Delta E_1 + \Delta E_2 + \Delta E_3 = 32115 - 30049 + 0 = 2066\ J$	