HCMC UNIVERSITY OF TECHNOLOGY AND EDUCATION
Faculty for High Quality Training
GROUP OF PHYSICS

FINAL EXAMINATION
SEMESTER 1 – ACADEMIC YEAR 2020-2021
Course name: **Principles of Physics 1**
Course ID: PHYS130902E
Exam code: 01 Number of pages: 02
Duration: 90 minutes.

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

Question 1: (0.5 marks/10)
Which of the following gives the correct SI units for force?
(a) $kg.m/s^2$ (b) $kg.m^2/s^2$ (c) $kg/m.s^2$ (d) $kg.m^2/s$
(e) None of those answers

Question 2: (0.5 marks/10)
The momentum of an object is increased by a factor of 4 in magnitude. By what factor is its kinetic energy changed?
(a) 16 (b) 8 (c) 4 (d) 2 (e) 1

Question 3: (0.5 marks/10)
A racing car starts from rest at t = 0 and reaches a final speed v at time t. If the acceleration of the car is constant during this time, which of the following statements are true?
(a) The car travels a distance vt.
(b) The average speed of the car is v/2.
(c) The magnitude of the acceleration of the car is v/t.
(d) The velocity of the car remains constant.
(e) None of statements (a) through (d) is true.

Question 4: (0.5 marks/10)
An ideal gas is compressed to half its initial volume by means of several possible processes. Which of the following processes results in the most work done on the gas?
(a) Isothermal (b) Adiabatic
(c) Isobaric (d) The work done is independent of the process

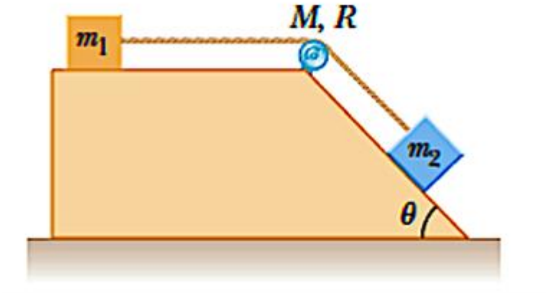
Question 5: (1.0 mark/10)
Identify action–reaction pairs in the following situations:
(a) A snowball hits a girl in the back.
(b) A fly collides with the windshield of a moving bus.

Question 6: (1.0 mark/10)
An ice skater starts a spin with her arms stretched out to the sides. She balances on the tip of one skate to turn without friction. She then pulls her arms in close to her body. In the process of her doing so, what happens to her kinetic energy?

Question 7: (2.0 marks/10)
A 40.0 kg box initially at rest is pushed 5.00 m along a rough, horizontal floor with a constant applied horizontal force of 130 N. The coefficient of kinetic friction between the box and floor is μ_k = 0.300. Find
(a) The work done by the applied force.
(b) The increase in internal energy in the box–floor system as a result of friction.
(c) The change in kinetic energy of the box.
(d) The final speed of the box.

Question 8: (2.0 marks/10)
A block of mass m_1 = 2.00 kg and a block of mass m_2 = 6.00 kg are connected by a massless string over a pulley in the shape of a solid disk having radius R = 0.250 m and mass M = 10.0 kg. The

fixed, wedge shaped ramp makes an angle of θ = 30.0º as shown in the figure below. The coefficient of kinetic friction is $\mu_k = 0.360$ for both blocks.
(a) Draw force diagrams of both blocks and of the pulley.
(b) Determine the acceleration of the two blocks.
(c) Determine the tensions in the string on both sides of the pulley.



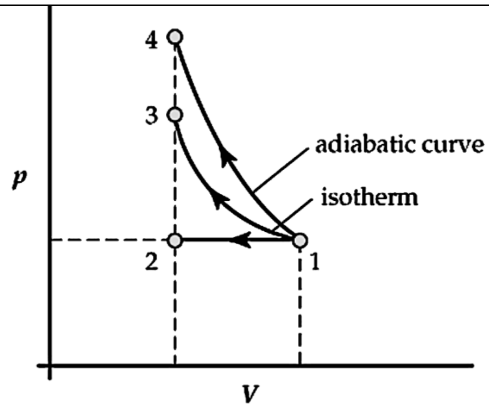
Question 9: (2.0 marks/10)
A heat engine operates in a Carnot cycle between 80.0°C and 350°C. It absorbs 21000 J of energy per cycle from the hot reservoir. The duration of each cycle is 1.00 s.
(a) Find the efficiency of the engine.
(b) What is the mechanical power output of this engine?
(c) How much energy does it expel in each cycle by heat?

The universal gas constant is R = 8.31 J/mol.K
The magnitude of the free-fall acceleration is g = 9.80 m/s^2.

Learning outcome mapping	Assessed in
[ELO 1.1]: Understanding various concepts, theorems, and laws related to classical mechanics and fluid mechanics. [ELO 3.1]: To express the learned knowledge by problem solving capability and answer questions related to the concepts learned.	Questions 1, 2, 3, 5, 6
[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 7, 8
[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, 9

6th January, 2021
Approved by program chair
(signed and named)

KEYS AND SCORES
For Questions in Final Exam of Principles of Physics 1
Edited by: Do Quang Binh

<table>
<tr><th>Question</th><th>Answer</th><th>Mark</th></tr>
<tr><td>1</td><td>$(\boldsymbol{A})\ kg.m/s^2$</td><td>0.5</td></tr>
<tr><td>2</td><td>$(\boldsymbol{A})$ 16
Due to the relationship between the magnitude of momentum and the kinetic energy:
$K = \frac{p^2}{2m}$</td><td>0.5</td></tr>
<tr><td>3</td><td>In this case, the acceleration is a nonzero constant $a \neq 0$, so only statements $(B)\ and\ (C)$ are true.</td><td>0.5</td></tr>
<tr><td>4</td><td>

$(\boldsymbol{B})$ Adiabatic
The work done on a gas equals the negative of the area under the process curve in the PV diagram.</td><td>0.5</td></tr>
<tr><td>5</td><td>(a) The action is the force exerted on the girl's back by the snowball; the reaction is the force exerted on the snowball by the girl's back.
(b) The action is the force exerted on the windshield by the fly; the reaction is the force exerted on the fly by the windshield..</td><td>0.5
0.5</td></tr>
<tr><td>6</td><td>Because the ice skater spins about the trunk of her body (the rotation axis) without friction, no external torques act on her body. The conservation of angular momentum shows that
$I\omega = constant$
As the mass distribution of the ice skater is closer to her body when she pulls her arms in close to her body, the moment of inertia about the rotation axis decreases resulting in her angular speed increasing. Then her kinetic energy $K = \frac{1}{2}I\omega^2$ will increase.</td><td>1.0</td></tr>
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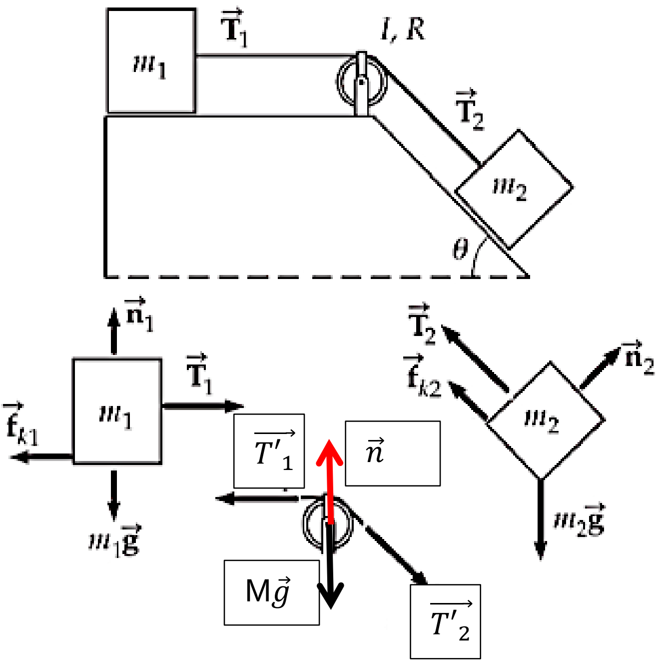
7	a) The applied force and the motion are both horizontal. $$W_F = Fd\cos\theta = 130 \times 5.00 \times \cos 0^o = 650\,J$$ b) For the box: $$\sum F_y = ma_y \Leftrightarrow n - F_g = 0 \Leftrightarrow n = mg = 40.0 \times 9.8 = 392\,N$$ $$f_k = \mu_k n = 0.300 \times 392 = 117.6\,N$$ The change in the internal energy in the box–floor system as a result of friction. $$\Delta E_{int} = f_k d = 117.6 \times 5.00 = 588.0\,J$$ c) For a nonisolated system including the box and the floor, the change in the kinetic energy of the system is: $$\Delta K = \sum W_{other} - \Delta E_{int} = 650.0 - 588.0 = 62.0\,J$$ d) The final speed of the box. $$\Delta K = K_f - K_i \Leftrightarrow 62.0 = \frac{1}{2}mv_f^2 - 0 \Rightarrow v_f = 1.76\ m/s$$	0.5 0.25 0.5 0.5 0.25
8	**a)** Draw force diagrams of both blocks and of the pulley.  The magnitudes of the accelerations of m_1 and m_2 are the same $a_1 = a_2 = a$. And $T'_1 = T_1$, $T'_2 = T_2$ **b)** For m_1: $$\sum F_y = m_1 a_y \Leftrightarrow n_1 - m_1 g = 0 \Rightarrow n_1 = m_1 g$$ $$f_{k1} = \mu_k n_1 = \mu_k m_1 g$$ $$\sum F_x = m_1 a_x \Leftrightarrow -f_{k1} + T_1 = m_1 a \qquad \textbf{(1)}$$ For m_2: $$\sum F_{y'} = m_2 a_{y'} \Leftrightarrow n_2 - m_2 g\cos\theta = 0 \Rightarrow n_2 = m_2 g\cos\theta$$	0.5 0.25

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$$f_{k2} = \mu_k n_2 = \mu_k m_2 g \cos\theta$$

$$\sum F_{x'} = m_2 a_{x'} \Leftrightarrow -f_{k2} - T_2 + m_2 g \sin\theta = m_2 a \qquad \textbf{(2)}$$

For the pulley,

$$\sum \tau = I\alpha \Leftrightarrow -T_1 R + T_2 R = \frac{1}{2}MR^2\left(\frac{a}{R}\right) \Longrightarrow -T_1 + T_2 = \frac{1}{2}Ma \qquad \textbf{(3)}$$

Add equations **(1)**, **(2)** and **(3)** and substitute the expressions for f_{k1} and n_1; $-f_{k2}$ and n_2, we have:

$$-f_{k1} + T_1 + (-T_1 + T_2) - f_{k2} - T_2 + m_2 g \sin\theta = m_1 a + m_2 a + \frac{1}{2}Ma$$

$$\Leftrightarrow\ -f_{k1} - f_{k2} + m_2 g \sin\theta = \left(m_1 + m_2 + \frac{1}{2}M\right)a$$

$$\Leftrightarrow\ -\mu_k m_1 g - \mu_k m_2 g \cos\theta + m_2 g \sin\theta = \left(m_1 + m_2 + \frac{1}{2}M\right)a$$

$$\Leftrightarrow\ -\mu_k m_1 g - \mu_k m_2 g \cos\theta + m_2 g \sin\theta = \left(m_1 + m_2 + \frac{1}{2}M\right)a$$

$$a = \frac{m_2(\sin\theta - \mu_k\cos\theta) - \mu_k m_1}{m_1 + m_2 + \frac{1}{2}M}g$$

$$a = \frac{6\times(\sin 30^o - 0.360\times\cos 30^o) - 0.360\times 2}{2 + 6 + \frac{1}{2}\times 10}\times 9.80 = 0.309\ m/s^2$$

c) From equation **(1)**:

$$-f_{k1} + T_1 = m_1 a \Longrightarrow T_1 = \mu_k m_1 g + m_1 a = 0.360\times 2\times 9.80 + 2\times 0.309 = 7.67\ N$$

From equation **(2)**:

$$-T_1 + T_2 = \frac{1}{2}Ma \Longrightarrow T_2 = 7.67 + \frac{1}{2}\times 10\times 0.309 = 9.22\ N$$

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a) We have: $\begin{cases} T_c = 80^oC + 273 = 353\ K \\ T_h = 350^oC + 273 = 623\ K \end{cases}$

The efficiency of the Carnot engine is:

$$e_c = 1 - \frac{T_c}{T_h} = 1 - \frac{353}{623} = 0.433$$

b) The mechanical power output of this engine is (the duration of a cycle is Δt = 1s):

$$e_c = \frac{W_{eng}}{|Q_h|} \Longrightarrow P = W_{eng}/\Delta t = e_c\times|Q_h| = 0.433\times 21000 = 9093\ W$$

c) The energy expelled by heat in each cycle is:

$$e_c = \frac{|Q_h| - |Q_c|}{|Q_h|} \Leftrightarrow 0.433 = \frac{21000 - Q_c}{21000} \Longrightarrow |Q_c| = 11907\ J$$

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