HANOI UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF ENGINEERING PHYSICS

ADVANCED PROGRAMS - PHYSICS FINAL EXAM - SPRING 2020

Time: **90 minutes** Class code: **114767** Subject code: **PH1110**

Name:..DOB:....................ID:.....................

For Examiner's Use

Question:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	Total
Points:	4	8	7	5	5	5	10	11	55
Score:									

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm \omega\sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel	$C = C_1 + C_2 + \ldots$
energy of charged capacitor	$W = \frac{1}{2}QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1. The position vector of an ion is initially $\vec{\mathbf{r}}_0 = 5.0\,\hat{\mathbf{x}} - 6.0\,\hat{\mathbf{y}} + 2.0\,\hat{\mathbf{z}}$, and is $\vec{\mathbf{r}} = -2.0\,\hat{\mathbf{x}} + 8.0\,\hat{\mathbf{y}} - 2.0\,\hat{\mathbf{z}}$ two minutes later, all in meters. **4 p**

(**a**) In unit-vector notation, find the average velocity of the ion during the two minutes. [2]

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$\vec{\mathbf{v}} =$ . . . . $\mathrm{m\,s^{-1}}$

(**b**) State and explain whether or not it is possible to determine the average speed of the ion with the given information. [2]

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2. You throw a ball toward a wall at speed $22.0\,\mathrm{m\,s^{-1}}$ and at angle of $\theta_0 = 35°$ above the horizontal, as shown in **Fig. 2.1**. The wall is distance $d = 25.0\,\mathrm{m}$ from the release point of the ball. **8 p**

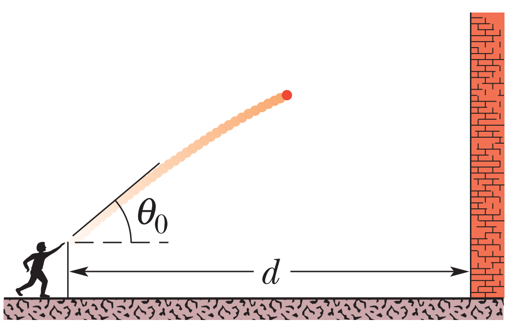

Fig. 2.1

(**a**) How far above the release point does the ball hit the wall? [3]

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(**b**) Determine, for the velocity of the ball as it hits the wall,

i. the horizontal component, [1]

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ii. the vertical component. [2]

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(**c**) State and explain if the ball has passed the highest point on its trajectory when it hits the wall. [2]

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3. For a particle moving around a point, suppose that the net torque acting on the particle and the angular momentum of the particle about the point are $\vec{\boldsymbol{\tau}}$ and $\vec{\mathbf{L}}$, respectively. **7 p**

(**a**) State the formulae for the definitions of $\vec{\boldsymbol{\tau}}$ and $\vec{\mathbf{L}}$. Explain your notations. [4]

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(**b**) Use the results in (**a**) to show that [3]

$$\vec{\boldsymbol{\tau}} = \dot{\vec{\mathbf{L}}} \equiv \frac{\mathrm{d}\vec{\mathbf{L}}}{\mathrm{d}t}$$

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4. A 75-kg petty thief wants to escape from a third-story jail window. Unfortunately, a makeshift rope made of sheets tied together can support a mass of only 58 kg. **5 p**

(**a**) How might the thief use this 'rope' to escape? [2]

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(**b**) Give a quantitative answer. [2]

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(**c**) What is the *inertia* of an object? [1]

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5. A ball of mass 0.440 kg moving east ($+x$ direction) with a speed of $3.80\,\mathrm{m\,s^{-1}}$ collides head-on with a 0.220-kg ball at rest. If the collision is perfectly elastic, what will be the speed and direction of each ball after the collision? [5]

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6. Rain is falling at the rate of $3.5\,\mathrm{cm\,h^{-1}}$ and accumulates in a pan. If the raindrops hit at $10.0\,\mathrm{m\,s^{-1}}$, estimate the force on the bottom of a $1.0\text{-}\mathrm{m^2}$ pan due to the impacting rain which we assume does not rebound. The density of water is $1.00 \times 10^3\,\mathrm{kg\,m^{-3}}$. [5]

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7. In **Fig. 7.1**, block 1 has mass $m_1 = 460\,\mathrm{g}$, block 2 has mass $m_2 = 500\,\mathrm{g}$, and the pulley, which is mounted on a horizontal axle with negligible friction, has radius $R = 5.00\,\mathrm{cm}$. **10 p**

When released from rest, block 2 falls $75.0\,\mathrm{cm}$ in $5.00\,\mathrm{s}$ without the cord slipping on the pulley.

(**a**) What is the magnitude of the acceleration of the blocks? [5]

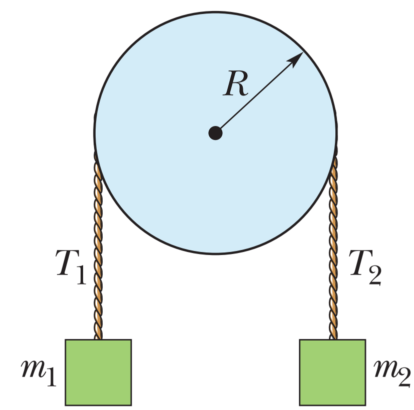

Fig. 7.1

(**b**) Calculate the tensions T_1 and T_2. [2]

(**c**) Determine the rotational inertia of the pulley. [3]

8. **11 p**

(**a**) The first law of thermodynamics may be expressed in the form $\Delta U = w + q$.

i. State, for a system, what is meant by: [2]

1. $+q$

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2. $+w$.

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ii. State what is represented by a negative value of ΔU. [1]

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(**b**) An ideal gas, sealed in a container, undergoes the cycle of changes shown in **Fig. 8.1**.

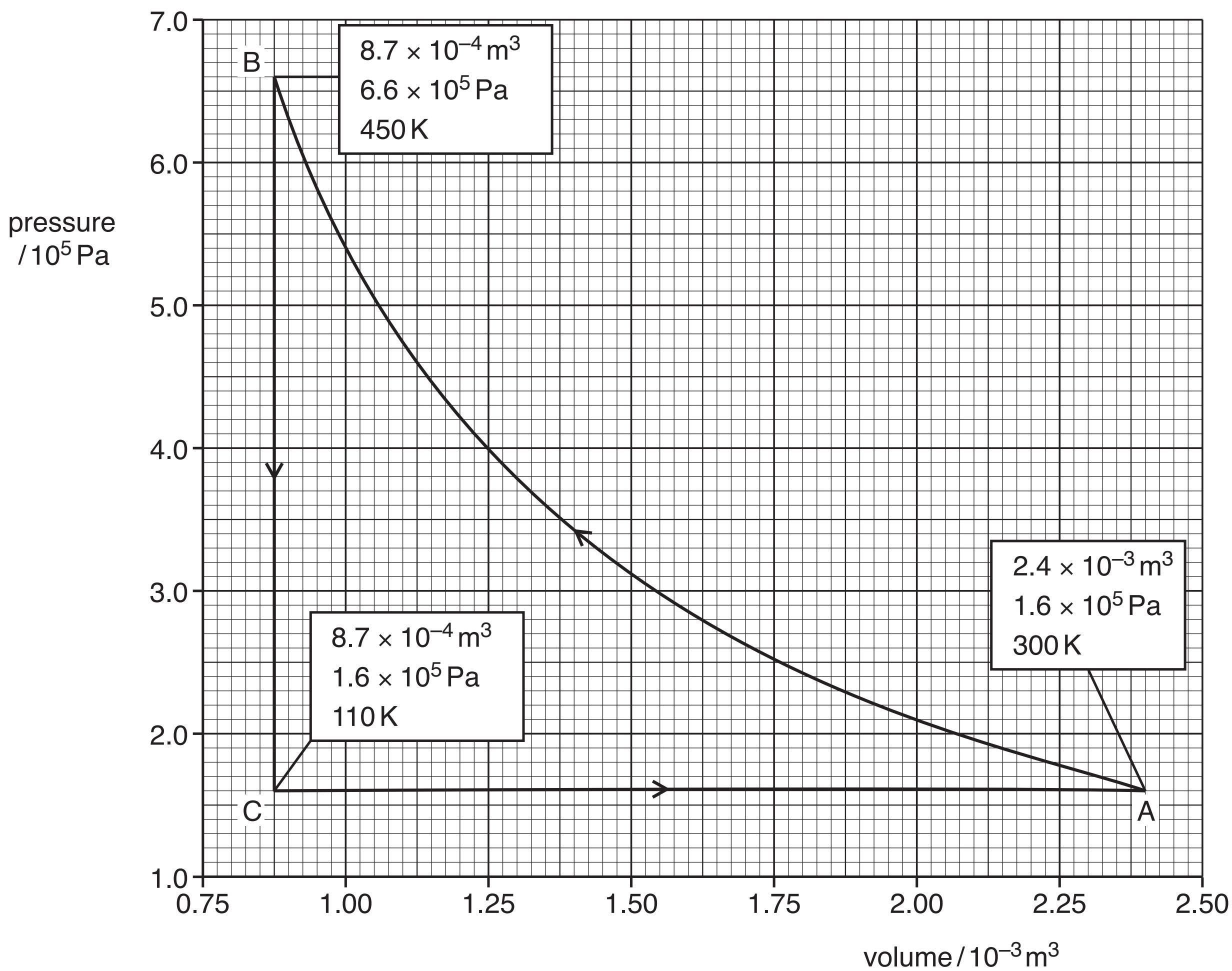

Fig. 8.1

At point A, the gas has volume $2.4 \times 10^{-3}\,\text{m}^3$, pressure $1.6 \times 10^5\,\text{Pa}$ and temperature 300 K.

The gas is compressed suddenly so that no thermal energy enters or leaves the gas during the compression. The amount of work done is 480 J so that, at point B, the gas has volume $8.7 \times 10^{-4}\,\mathrm{m}^3$, pressure 6.6×10^5 Pa and temperature 450 K.

The gas is now cooled at constant volume so that, between points B and C, 1100 J of thermal energy is transferred. At point C, the gas has pressure 1.6×10^5 Pa and temperature 110 K.

Finally, the gas is returned to point A.

i. State and explain the total change in internal energy of the gas for one complete cycle. [2]

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ii. Calculate the external work done on the gas during the expansion from C to A. [2]

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work done .... J

iii. Complete **Fig. 8.2** for the changes from: [4]

1. point A to point B
2. point B to point C
3. point C to point A.

change	$+q$/J	$+w$/J	ΔU/J
A $\rightarrow$ B	....	....	....
B $\rightarrow$ C	....	....	....
C $\rightarrow$ A	....	....	....

Fig. 8.2

Director of the Department of Theoretical Physics **Leturer**

Nam B. Le, Dr.