复旦大学力学系

2006～2007 学年第一学期期终考试试卷

□A 卷　　□B 卷

课程名称：__大学物理上__　　课程代码：__PHYS120001.06__

开课院系：__物理系__　　考试形式：__闭卷__

姓　名：________　学　号：________　专　业：________

（装订线内不要答题）

题 号	1	2	3	4	5	6	7	8	总 分
得 分									

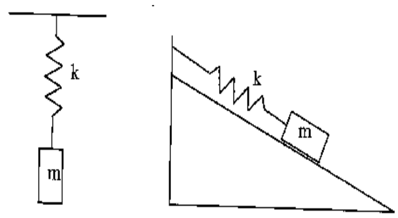
I. Fill the blank and choose the correct answer (33')

1. The equation of a transverse wave traveling along a very long string is given by y=(6.0 *cm*) sin[(2.0π *rad/m*)*x*+(4.0π *rad/s*)*t*]. The amplitude is_________,the wavelength is __________, the frequency is ___________, the speed is ___________,the direction of propagation of the wave is__________, the maximum transverse speed of a particle in the string is_____________.(6')

2. A crate with mass *m* is resting on a platform scale(磅秤). The gravitational constant at the place is *g*. After considering the Earth's rotation (with angular speed ω), we can read the weight of the crate from the scale with the value of ___________________.

3. A mass (*m*) on a spring (*k*) that obeys Hooke's law has a period of 0.50 seconds when hung vertically and allowed to oscillate freely. The mass/spring system is placed on a frictionless incline plane, as shown below. The natural period for this system is ______________________________.

(a) less than 0.50 seconds.
(b) greater than 0.50 seconds.
(c) Need to know angle of incline to determine answer.
(d) equal to 0.50 seconds.



4. A sound source produces a certain intensity. If you were to double your distance from it, the new intensity would be ______________.

(a) the same as before.　　(b) twice the original intensity
(c) one-quarter times the original intensity　　(d) half as much as it was originally
(e) 1.41 times less the original intensity.

5. A bird flying directly away from a birdwatcher and directly toward a distant cliff(悬崖) at a speed of 15 *m/s*. The bird produces a shrill cry whose frequency is 800 *Hz*. The frequency in the sound that the bird watcher hears directly from the bird is_______________;The frequency that the birdwatcher hears in the echo (回声) that is reflected from the cliff is__________________. (Sound speed is 340 *m/s*)

6. A nickel-steel rod at $21^\circ C$ is 0.62406 *m* in length. Raising the temperature to $31^\circ C$ produces an elongation of 121.6 μm. The coefficient of linear expansion is ________________.

7. The specific heat of many solids at very low temperatures varies with absolute temperature T according to the relation $c=AT^3$, where A is a constant. The heat energy needed to raise the temperature of a mass *m* of such a substance from T=0 to T=20K is ______________________.

8. Which type of ideal gas will have the largest value for $C_p - C_v$?________________________

(a) Monatomic (b) Diatomic (c) Polyatomic (d) The value will be the same for all.

9. Which of the following states can not express the second law of thermodynamics?__________

(a) You can not change completely heat energy into work.

(b) The entropy of an irreversible process never decreases.

(c) You can not transfer heat energy from a low-temperature reservoir to a higher temperature reservoir without doing work..

(d) The entropy of a closed system never decreases.

II. An observer is standing on a platform of length 65 m. A train passes at a relative speed of 0.80c moving parallel to the edge of the platform. The observer *S* notes that the front and back of the train simultaneously line up with the ends of the platform at a particular instant. (12')

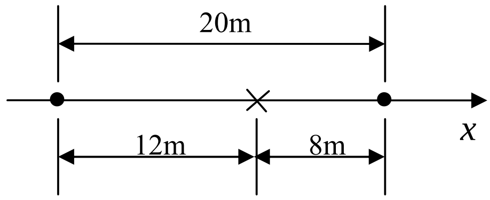
(a) According to *S*, what is the time necessary for the train to pass a particular point on the train?

(b) What is the rest length of the train?

(c) According to an observer *S'* on the train, what is the length of the platform?

III. The force of interaction between two atoms in certain diatomic molecules can be represented by $F= -a/r^2+b/r^3$ in which *a* and *b* are positive constants and *r* is the separation distance of the atoms. Then (a) find the separation at equilibrium; (b) for *small* oscillations about this equilibrium separation, write out the equation of the motion *(Hint: expand the force at equilibrium separation and do the first order approximation*) and find the solution for the equation; (c) find the period of the motion. (12')

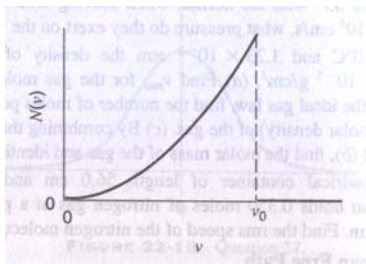
IV. Sources separated by 20 m vibrate according to the equations $y'_1 = 0.06\sin(\pi t)$ (m), $y'_2 = 0.02\sin(\pi t)$ (m). They send out waves along a rod of speed 3 m/s. What is the equation of motion of a particle 12m from the first source and 8 m from the second? (8')



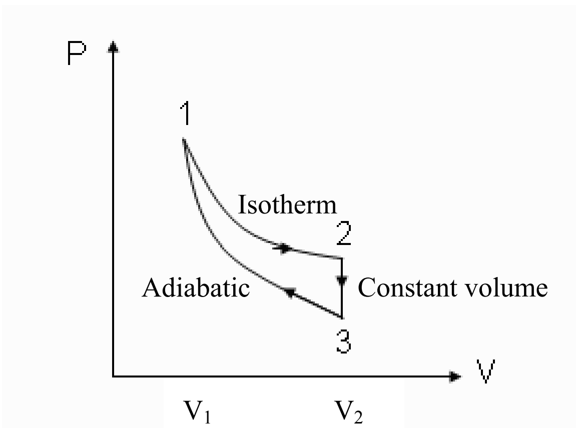
（装订线内不要答题）

V. The equation for a particular standing wave on a string is y=0.15sin(5*x*)cos(300*t*) m. Find the (a)amplitude of vibration at the antinode, (b)distance between nodes, (c)wavelength, and (d)frequency. (8')

VI. The figure shows a hypothetical speed distribution of N gas molecules with $N(v) = Cv^2$ for $0<v \leqslant v_0$ and $N(v) = 0$ for $v>v_0$. Find (a) an expression for C in terms of N and v_0, (b) the average speed of the particles, and (c) the rms speed of the particles. (12’)



VII. One mole of an ideal diatomic gas is caused to pass through the cycle shown on the pV diagram in below figure, where $V_2=3V_1$. Determine, in terms of p_1, V_1, T_1, and R: (a) ΔE_{int}, and ΔS for all three processes, (b) the efficiency of the cycle. (15’)



06-07 期末试卷答案(A卷)

I. 1. 3' 6'

amplitude: $y_m = 0.06\,m$

wavelength: $\lambda = \frac{2\pi}{k} = \frac{2\pi}{2\pi} = 1.0\,m$

frequency: $f = \frac{\omega}{2\pi} = \frac{4.0\pi}{2\pi} = 2\,HZ$

velocity: $v = \lambda f = 2\,m/s$

direction: in $-x$ direction

$u_y = y_m \omega = 0.06\,m \cdot 4.0\pi\,rad/s = 0.75\,m/s$.

3' 2. $mg - m\omega^2 R_E$, R_E, radius of earth

3' 3. d

3' 4. C

3' 5. (1) $\nu' = \frac{v}{v+v_{bird}} \nu = \frac{340}{340+15} \cdot 800 = 766\,HZ$

3' (2) $\nu'' = \frac{v}{v-v_{bird}} \cdot \nu = \frac{340}{340-15} \cdot 800 = 837\,HZ$

3' 6. $\alpha = \frac{1}{L}\frac{\Delta L}{\Delta T} = \frac{121.6\times10^{-6}}{0.62406\times10^{\circ}C} = 19.5\times10^{-6}\,{}^{\circ}C^{-1}$

3' 7. $\int dQ = \int_0^{20} mc\,dT = \int_0^{20} m \cdot AT^3 dT = 40000\,Am$

3' 8. d

3' 9. b

II. 12'

(a) $\Delta t_0 = \frac{L}{0.8c} = \frac{65}{2.4\times10^8} = 0.27\,\mu s$

(b) $L_0 = \frac{L}{\sqrt{1-u^2/c^2}} = \frac{65}{\sqrt{1-(0.8)^2}} = 108\,m$

(c) $D = D_0\sqrt{1-u^2/c^2} = 65\sqrt{1-0.8^2} = 39\,m$

III. 12'

4' (a). $F=0 \Rightarrow r_0 = b/a$.

4' (b) $f(r) = f(r_0) + f'(r)\big|_{r=r_0} \cdot \Delta r$ ~~$+ \frac{1}{2!} f''(r)\big|_{r=r_0} \Delta r$~~

$= 0 + f'(r)\big|_{r_0} \cdot \Delta r$

$f'(r)\big|_{r_0} = -a^4/b^3$

Eq. of motion:

$m\ddot{\Delta r} = f'(r)\cdot\Delta r$

$= -a^4/b^3 \cdot \Delta r$

$\Delta r = A\cos(\omega t + \varphi)$

$\omega = \sqrt{a^4/(b^3 m)}$

4' (c) $T = \frac{2\pi}{\omega} = 2\pi\sqrt{mb^3/a^4}$

IV. 8'

Source 1 (left to right):

$y_1' = A_1 \sin(\omega t - k_1 x)$

Source 2 (right to left):

$y_2' = A_2 \sin(\omega t + k_2 x)$

$k_1 = \frac{2\pi}{\lambda} = \frac{2\pi}{T\cdot v}$, $T = \frac{2\pi}{\omega}$

$= \frac{\omega}{v} = \frac{\pi}{3}$

$k_2 = \frac{\omega}{v} = \frac{\pi}{3}$

Wave at the particle:

$y = y_1' + y_2'$

$= 0.06\sin(\pi t - \frac{\pi}{3}\cdot 12) + 0.02\sin(\pi t + \frac{\pi}{3}(-8))$

$= 0.06\sin(\pi t) + 0.02\sin(\pi t - \frac{2}{3}\pi)$ 展开

$= 0.05\sin\pi t - 0.0173\cos\pi t$

V. (a) 0.15m

8'

(b) $5x = 0$, $5x = \pi$

$x = 0$ $\quad x = \frac{\pi}{5}$

$\therefore \Delta x = \frac{\pi}{5} = 0.628m$

(c) $k = 5$ $\quad k = \frac{2\pi}{\lambda} = 5$

$\Rightarrow \lambda = \frac{2\pi}{5} = 1.26m$

(d) $f = \frac{\omega}{2\pi} = \frac{300}{2\pi} = 47.7Hz$

VI. (1) $N = \int_0^{v_0} N(v)dv = \int_0^{v_0} c\cdot v^2 dv$

12'

$= \frac{1}{3}c\cdot v_0^3$

$\therefore c = \frac{3N}{v_0^3}$

(2) $v_{av} = \frac{1}{N}\int_0^{v_0} N(v)\, v\, dv$

$= \frac{1}{N}\int_0^{v_0} c\cdot v^2\cdot v\, dv$

$= \frac{1}{N}\int_0^{v_0} v^3\cdot c\, dv = c\cdot\frac{1}{4}v_0^4$

$= \frac{3}{4}v_0$

(3) $v_{rms} = \sqrt{(v^2)_{av}} = \sqrt{\frac{1}{N}\int_0^{v_0} c\cdot v^2\cdot v^2 dv}$

$= \left(\frac{1}{N}\int_0^{v_0} c v^4 dv\right)^{\frac{1}{2}} = \sqrt{\frac{3}{5}}v_0$

VII. (a)

15'

point 1: P_1, V_1, T_1

point 2: $T_2 = T_1$, $V_2 = 3V_1$, $P_2 = \frac{1}{3}P_1$

point 3: $P_1V_1^\gamma = P_3V_3^\gamma$

$\gamma = \frac{C_p}{C_v} = \frac{\frac{7}{2}R}{\frac{5}{2}R} = \frac{7}{5} = 1.4$

$V_3 = 3V_1$

$\therefore P_3 = P_1\left(\frac{V_1}{V_3}\right)^\gamma = P_1\cdot\left(\frac{1}{3}\right)^{1.4}$

$= 0.215P_1$

$T_3 = 0.646T_1$

$= 0.215\times 3T_1$

$1\to 2$ $\Delta E_{int} = 0$

吸 $\Delta S_{1\to2} = \frac{\Delta Q}{T_1} = \frac{-\Delta W}{T_1} = \frac{\int p\,dV}{T_1}$

$\int p\,dV = \int_{V_1}^{3V_1}\frac{nRT}{V}dV = nRT_1\ln 3$

$\therefore \Delta S_{1\to2} = \frac{nRT_1\ln3}{T_1} = R\ln 3$

$= 1.1R$

$2\to 3$ $\Delta E_{int} = nR\cdot\frac{5}{2}\Delta T$

放

$= R\cdot\frac{5}{2}\cdot(T_3 - T_2)$

$= R\cdot\frac{5}{2}\cdot(0.646T_1 - T_1)$

$= -0.885P_1V_1 = -0.885RT_1$

$\Delta S = \int\frac{\Delta Q}{T} = \int\frac{nR\cdot\frac{5}{2}dT}{T}$

$= \frac{5}{2}nR\ln T\Big|_{T_1}^{0.646T_1}$

$= \frac{5}{2}R\cdot\ln 0.646$

$= -1.1R$.

$3\to 1$, $\Delta E_{int} = +0.885RT_1$

$\Delta S = 0$.

$\varepsilon = \frac{W}{Q_{吸}} = \frac{Q_{吸} - Q_{放}}{Q_{吸}} = 1 - \frac{0.885RT_1}{(\ln 3)RT_1}$

$= 20\%$