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Principles of Physics I
PHY1321
PHY1331

Department of Physics

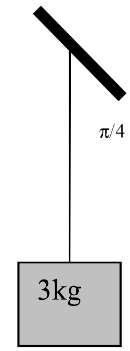
Instructor: Dr. Andrzej Czajkowski
Final Exam
December 20 2011

Closed book exam
10 pages
33 questions of equal value
15 correct answers pass the test!

Duration: 3 hrs

RETURN ONLY THE SCANTRON SHEET!

1 3kg mass hangs an the string. String makes angle π/4 with the ceiling. The tension in the string is:



A 3N B 29.4N C 0N 14.7N E none of the above

2 The position of a particle of mass 2kg is given by $\vec{r} = 3t\vec{i} - 4t^2\vec{j} + 2\vec{k}$ (t is in seconds and r in meters). The magnitude of the instantaneous acceleration at t = 2s is:

A 8m/s^2 B 15m/s^2 C $\vec{a} = -8\vec{j}$ D -8 m/s^2
E none of the above

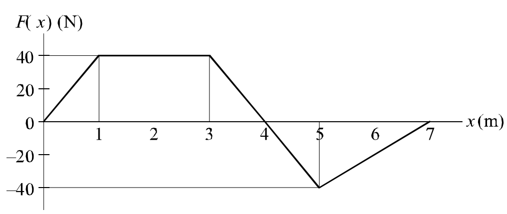
3 A particle of mass M, is at the origin while the particle of the mass 4M is at x=1m. The centre of mass of this system is at:
A x=0.1m B x=0.2m C x=0.4 m D 0.8 m E none of the above.

4. A cart of mass M moving at speed v collides with another stationary cart of mass 3M on air track (no friction), and the two stick together after the collision. What is their velocity after colliding?
A 0.5 v B 0.25v C -0.25v D -v E none of the above

5. A constant force of 12 N in the positive *x* direction acts on a 4.0-kg object as it moves from the origin to the point (6**i** – 8**j**) m. How much work is done by the given force during this displacement?

A) +60 J B) +84 J C) +48 J D) +57 J E) +72 J

6 An object moves from $x = 0$ m to $x = 7$ m subject to the force shown in the diagram. How much work in J is done on the object by the force when the object moves from x=4m to x=5m ?



A. 40 B. 20 C. 0
D. -20 E. -40

7. The work done in the expansion from an initial to a final state

A. depends only on the end point.

B. is independent of the path.

C. is the slope of a PV curve.

D equals P(V_F – V_i)

E. is the area under the curve of a PV diagram.

8. In order for two objects to have the same temperature, they must

a. be in thermal equilibrium.
b. be in thermal contact with each other.
c. have the same relative "hotness" or "coldness" when touched.
d. have all of the properties listed above.
e. have only properties (b) and (c) above.

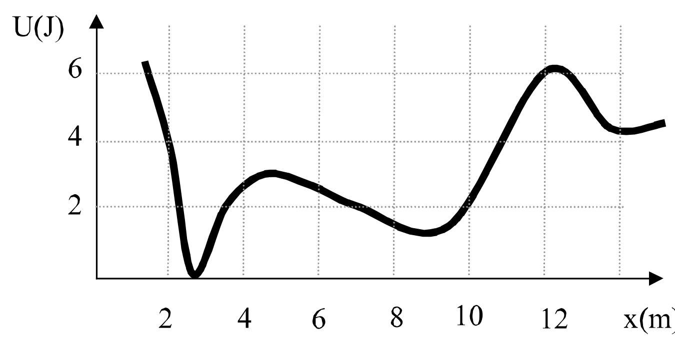
9. A gasoline engine absorbs 2500 J of heat and performs 1000 J of mechanical work in each cycle. The efficiency of the engine is

a.80% b.60% c.50% d.40% e.20%

10. A Carnot cycle, operating as a heat engine, consists , in the order given, of

a. an isothermal expansion, an isothermal compression, an adiabatic expansion and an adiabatic compression.
b. an adiabatic expansion, an adiabatic compression, an isothermal expansion and an isothermal compression.
c. an isothermal expansion, an adiabatic compression, an isothermal compression and an adiabatic expansion.
d. an adiabatic compression, an isothermal compression, an isothermal expansion and an adiabatic expansion.
e. an isothermal expansion, an adiabatic expansion, an isothermal compression and an adiabatic compression

11 When the particle is at x= 2m it has 1J of kinetic energy, and moves under influence of conservative force whose potential energy is shown in the diagram. What is its kinetic energy, and what is the direction of the force acting on the particle at x=10m?

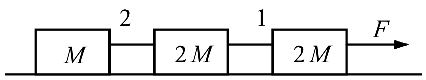


A) K=0J, F is negative
B) K=2J, F is positive
C) K= 3J, F is negative
D) K= 4J, F is positive
E) none of the above

12. A bullet is fired through a board, 14.0 cm thick, with its line of motion perpendicular to the face of the board. If it enters with a speed of 450 m/s and emerges with a speed of 220 m/s, what is the bullet's acceleration as it passes through the board?

A) –500 km/s^2 B) –550 km/s^2 C) –360 km/s^2
D) –520 km/s^2 E) –275 km/s^2

13. The horizontal surface on which the objects slide is frictionless. If $M = 2.0\ \text{kg}$, the tension in string 1 is 12 N. Determine F in N.



a. 25 b. 20 c. 30 d. 35 e. 40

14. A fish weighs 10.0 N at rest. When it is weighed on a spring scale in an elevator accelerating upwards at $2.60\ \text{m/s}^2$, the scale reads ___ N.

a. 7.35 b. 10.7 c. 11.7 d. 12.7 e. 13.7

15. The specific heat at constant volume at 0°C of one mole of an ideal diatomic gas is

a. $\frac{1}{2}R$. b. R. c. $\frac{3}{2}R$. d. $2R$. e. $\frac{5}{2}R$.

16 Some species of whales can dive to depths of 1 kilometer. What is the total pressure they experience at this depth? (ρ_{sea} = 1020 kg/m^3 and 10^5 N/m^2 = 1 ATM.)

A) 9 ATM B) 90 ATM C) 101 ATM D) 111ATM E)130 ATM

17. A hole is punched in a full milk carton, 10 cm below the top. What is the initial velocity of outflow?

A 1.4 m/s B 2.0 m/s C 2.8 m/s D 3.9 m/s E 2.8 m/s

18 A heat pump with a coefficient of performance of 4.9 absorbs heat from the atmosphere at a rate of 30 kW. At what rate is it doing work?

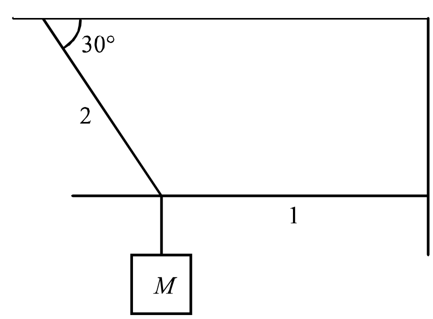
A 6 kW B 147 kW C 117 kW
D 36 kW E none of the above

19 Five moles of an ideal gas expands isothermally at 100°C to five times its initial volume. Find the heat flow into the system.

A) 2.5×10^4 J B) 1.1×10^4 J C) 6.7×10^3 J D) 2.9×10^3 J E) 7.0×10^2 J

20. If $M = 2.0\ \text{kg}$, what is the tension in N in string 1?

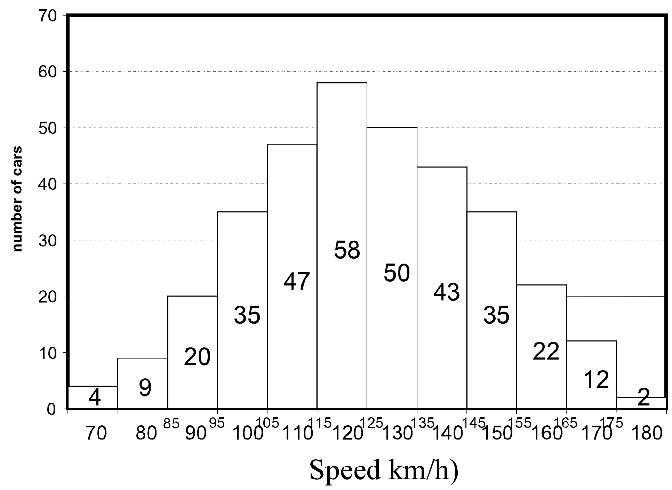
a. 1.2 b. 11 c. 34
d. 3.5 e. 40



21 In an adiabatic process 16 J of work are done on each mole of a gas. If the gas has 5 degrees of freedom, how much does its temperature change? Answer in terms of R.

A) 40/R (K) B) 11.43/R (K) C) 6.4/R (K)
D) 3.2/R(K) E) none of the above

22 The distribution of car speeds measured by a Police patrol for a particular stretch of the 401 highway between Kingston and Ottawa is shown on the figure. Which of the following conclusions about the v_{rms} [root mean square speed], and the P (85;105) [probability that the car has speed between 85km/h and 105 km/h] are true:

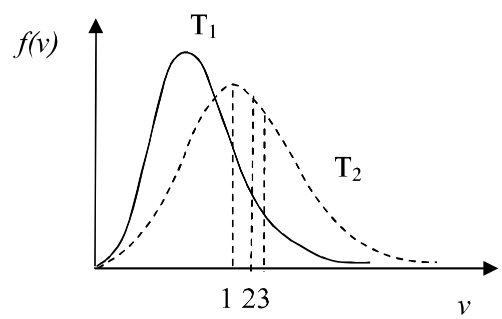


A v_{rms} =127km/h P(85,105) = 0.16
B v_{rms} =120km/h P(85,105) = 0.16
C v_{rms} =125km/h P(85,105) = 0.84
D v_{rms} =127km/h P(85,105) = 0.66
E none of the above

23. A 0.28 kg stone you throw rises 34.3 m in the air. The impulse your hand receives from the stone while it throws the stone is

A. $2.7 N \cdot s$, up. B. $2.7 N \cdot s$, down. C. $7.3 N \cdot s$, up.
D. $7.3 N \cdot s$, down. E. $9.6 N \cdot s$, up.

24. The figure shows the distribution of the molecular speeds of gas for two different temperatures T_1(solid) and T_2 (dashed). Which of the following sentences is true:



a) $T_1 < T_2$, and the point labeled "1" corresponds to the average speed of molecules whose temperature is T_2

b) $T_1 > T_2$ and the point labeled "2" corresponds to the average speed of molecules whose temperature is T_2

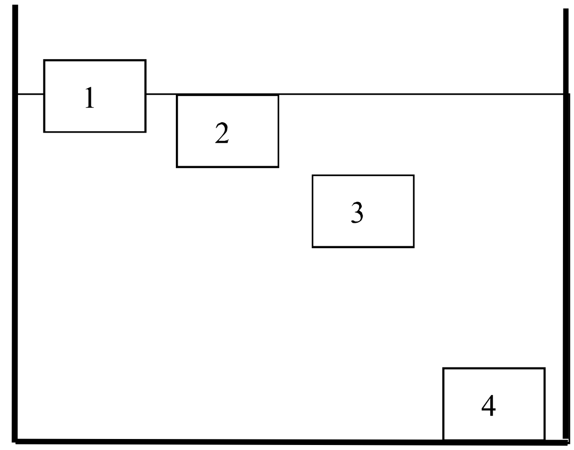
c) $T_1 > T_2$ and the point labeled "2" corresponds to the most probable speed of molecules at T_2

d) $T_1 < T_2$, and the point labeled "1" corresponds to the average speed of molecules at T_2

e) $T_1 < T_2$, and the point labeled "1" corresponds to the most probable speed of molecules at T_2

25. A 0.60 kg mass is swung in a vertical circle. It is fastened to a string 0.35 m long. What is the tension in the string in N at the bottom of the circle when the speed of the mass at that point is 5.5 m/s?
A. 35 B. 43 C. 49 D. 58 E. 61

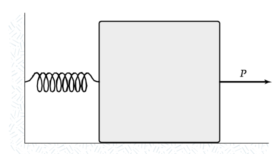
26 Four objects of the same volume are placed carefully in the container filled with water (shown on the figure). None of the object is moving with respect to the water. Which of the following statements about the masses of these objects is true:



A) m(1) = m(2) < m(3) < m(4)
B) m(1) ≤ m(2) < m(3) < m(4)
C) m(1) < m(2) = m(3) < m(4)
D) m(1) < m(2) = m(3) = m(4)
E) m(1) < m(2) = m(3) ≤ m(4)

27 A 12-kg block on a horizontal frictionless surface is attached a light spring (force constant = 0.80 kN/m). The block is initially at rest at its equilibrium position when a force (magnitude *P* = 80 N) acting parallel to the surface is applied to the block, as shown. What is the speed of the block when it is 13 cm from its equilibrium position?

A 0.78 m/s
B 0.81 m/s
C 0.71 m/s
D 0.58 m/s
E 0.64 m/s



28. An 8,000-kg aluminum flagpole 100-m long is heated by the sun from a temperature of 10°C to 20°C. Find the work done (in J) by the aluminum if the linear expansion coefficient is 24×10^{-6} $(°C)^{-1}$. (The density of aluminum is 2.7×10^{3} kg/m^3 and 1 atm = 1.0×10^{5} N/m^2.)

A. 287 **B**. 425 **C**. 213 **D**. 710 **E**.626

29 100 grams of molten lead (600°C) is used to make musket balls. If the lead shot is allowed to cool to room temperature (21°C), what is the change in entropy (in J/K) of the lead? (For the specific heat of molten and solid lead use 1.29 J/g °C; the latent heat of fusion and the melting point of lead are 2.45×10^{4} J/kg and 327°C.)

a. –140 **b**. –252 **c**. –302 **d**.–429 **e**.–100

30 A 25 g lead bullet at 0°C moves at 375 m/s and strikes a block of ice at 0°C. What quantity of ice in kg is melted if all of the kinetic energy of the bullet is converted to heat? The block of ice does not move. (The latent heat of fusion of ice is 80 kcal/kg and the specific heat of lead is $0.0305 \text{ kcal/kg}\cdot°\text{C}$. $1 \text{ cal} = 4.186 \text{ J}$)

A 4.21×10^{-3} B 5.89×10^{-3} C 4.98×10^{-3} <u>D 5.25×10^{-3}</u>
E 5.18×10^{-3}

31 A potter's wheel (a solid, uniform disk) of mass 6.1 kg and radius 0.65 m spins about its central axis. A 2.1 kg lump of clay is dropped onto the wheel at a distance 0.41 m from the axis. It sticks to the wheel and rotates with it Calculate the moment of inertia of the system.

A 1.3 kg · m^2 B 0.40 kg · m^2 C 2.2 kg · m^2 <u>D 1.6 kg · m^2</u>
E none of the above

32 A solid, uniform sphere of mass 2.0 kg and radius 1.7 m rolls without slipping down an inclined plane of height 7.0 m. What is the angular velocity of the sphere at the bottom of the inclined plane?

<u>A 5.8 rad/s</u> B 9.9 rad/s C 11.0 rad/s D 7.0 rad/s E none of the above

33. A 5-g coin, is dropped from a 300-m building. If it reaches a terminal velocity of 45 m/s, and the rest of the energy is converted to heating the coin, what is the change in temperature (in K) of the coin? (The specific heat of copper is 387 J/kg °C.) What is the entropy change associated with this heating (coin initial Temperature was 300K) ?

A ΔT=9K; ΔS= 0.062J/K B ΔT=2K; ΔS=0.023J/K <u>CΔT= 5K; ΔS= 0.032J/K</u>
D ΔT=21K; ΔS=0.090J/K E none of the above

Mechanics

$v_x = \frac{dx}{dt}$ $\qquad \vec{v} = \frac{d\vec{r}}{dt}$

$a_x = \frac{dv_x}{dt}$ $\qquad \vec{a} = \frac{d\vec{v}}{dt}$

$\vec{r}_f = \vec{r}_o + \vec{v}_o t + \frac{1}{2}\vec{a}t^2$

$a_t = \frac{dv}{dt}$ $\qquad a_c = \frac{v^2}{r}$

$\vec{F} = m\vec{a}$ $\qquad \vec{F}_o = -b\vec{v}$

$f = \mu N$ $\qquad R = \frac{1}{2}D\rho A v^2$

$F_B = \rho_l V.g$

$\vec{F} = -k\vec{x}$

$W = \int \vec{F}.d\vec{s}$

$k = \frac{mv^2}{2}$ $\qquad U_g = mgh$ $\qquad U_e = \frac{1}{2}kx^2$

$\vec{P} = m\vec{v}$ $\qquad \vec{F} = \frac{d\vec{p}}{dt}$

$\vec{r}_{CM} = \frac{\sum m_i \vec{r}_i}{M}$ $\qquad r_{CM} = \frac{\int r dm}{M}$

$V = \frac{4}{3}\pi r^3$ $\qquad A = 4\pi r^2$ $\qquad A = \pi r^2$ $\qquad C = 2\pi r$

Fluid Mechanics:

$p = p_o + \rho g h$ $\qquad A_1 v_1 = A_2 v_2$ $\qquad p_o + \rho g y + \frac{1}{2}\rho v^2 = const$

Rotational motion About a Fixed Axis

Angular speed $\omega = {d\theta}/{dt}$

Angular acceleration $\alpha = {dw}/{dt}$

Net torque $\sum \tau = I\alpha$

$$\text{If } \alpha = const. \begin{cases} \omega_f = \omega_i + \alpha t \\ \theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2 \\ \omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i) \end{cases}$$

Work $W = \int_{\theta_i}^{\theta_f} \tau \quad d\theta$

Rotational kinetic energy $K_R = \frac{1}{2} I\omega^2$

Power $P = \tau\,\omega$

Angular momentum $L = I\omega$

Net torque $\sum \tau = {dL}/{dt}$

Circular Hoop $I_{CM} = MR^2$

Hollow cylinder $I_{CM} = \frac{1}{2} M(R_1^2 + R_2^2)$

where R_1: inner radius, R_2: outer radius

Solid cylinder or disc $I_{CM} = \frac{1}{2} MR^2$

Thin Rectangle $I_{CM} = \frac{1}{12} M(a^2 + b^2)$

Long thin rod with rotational axis through center $I_{CM} = \frac{1}{12} ML^2$

Long thin rod with rotational axis through edge $I_{CM} = \frac{1}{3} ML^2$

Solid sphere $I_{CM} = \frac{2}{5} MR^2$

Thin spherical shell $I_{CM} = \frac{2}{3} MR^2$

THERMODYNAMICS

Probability of finding the speed of a particle in the range (v;v+dv)is:

$$P(v)dv = 4\pi\left[\frac{1}{2\pi}\frac{m}{kT}\right]^{\frac{3}{2}} v^2 e^{-\frac{mv^2}{2kT}} dv$$

$$v_{MP} = \left[\frac{2kT}{m}\right]^{\frac{1}{2}} \qquad v_{rms} = \left[\frac{3kT}{m}\right]^{\frac{1}{2}} \qquad v_{avg} = \left[\frac{8kT}{\pi m}\right]^{\frac{1}{2}}$$

$$p = \frac{1}{3}\rho < v^2 > \qquad \rho = \frac{Nm}{V}$$

Integrals:

$$\int_0^{+\infty} e^{-ax^2} dx = \frac{1}{2}\sqrt{\frac{\pi}{a}} \qquad \int_0^{+\infty} x e^{-ax^2} dx = \frac{1}{2a} \qquad \int_0^{+\infty} x^2 e^{-ax^2} dx = \frac{1}{4}\sqrt{\frac{\pi}{a^3}}$$

$$\int_0^{+\infty} x^3 e^{-ax^2} dx = \frac{1}{2a^2} \qquad \int_0^{+\infty} x^4 e^{-ax^2} dx = \frac{3}{8}\sqrt{\frac{\pi}{a^5}} \qquad \int_0^{+\infty} \frac{x^3}{e^x - 1} dx = \frac{\pi^4}{15}$$

ΔEint = Q + W $\qquad pV=nRT \qquad \Delta S = \int \frac{dQ}{T}$

Change	ΔEint	W	Q	ΔS
P = const	$nC_v \Delta T$	$-p(V_f-V_i)$	$nC_p \Delta T$	$nC_p \ln\frac{T_f}{T_i}$
V = const	$nC_v \Delta T$	0	$nC_v \Delta T$	$nC_V \ln\frac{T_f}{T_i}$
T = const	0	$-nRT\ln\frac{V_f}{V_i}$	$nRT\ln\frac{V_f}{V_i}$	$nR\ln\frac{V_f}{V_i}$
Q = 0	$nC_v \Delta T$	$\frac{1}{\gamma-1}\left(p_f V_f - p_i V_i\right)$	0	0

$$pV^\gamma = const. \qquad \gamma = \frac{C_P}{C_V} \qquad C_p - C_v = R$$

$$\epsilon_{CRN} = \frac{W}{Q} = \left|\frac{Q_H - Q_L}{Q_H}\right| = 1 - \frac{T_C}{T_H}$$

COP = $\frac{\text{what we want}}{\text{what we pay for it}}$

$\Delta L = \alpha L \Delta T \qquad \Delta S = \beta S \Delta T \qquad \Delta V = \gamma V \Delta T$

$P = e\,\sigma\, A\, T^4$; $\sigma = 5.67\text{x}\ 10^{-8}$W/(K^{4}m^2) $\qquad P = kA\left|\frac{dT}{dx}\right|$

Q = mcΔT $\qquad$ Q = Lm

c(water) = 4186 J/(kg C); c(ice) = 2090 J/(kg C); c(steam) = 2010J/(kg C)

L(melting) = $3.33\text{x}10^5$ J/kg $\qquad$ L (vaporization) = $2.26\text{x}10^6$ J/kg