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Principles of Physics I
PHY1321
PHY1331

Department of Physics

Instructor: Dr. Andrzej Czajkowski
Final Exam
December 13 2012

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

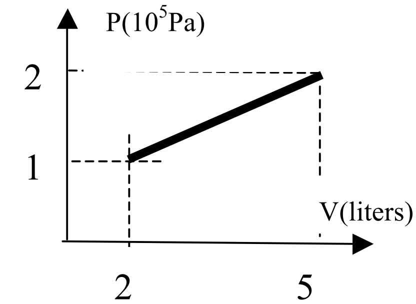
A 15m/s B 10m/s C $\vec{v} = 3\vec{i} - 16\vec{j}$ D $\vec{v} = 3\vec{i} - 8t\vec{j}$

E none of the above

2 The p-V diagram below represents a particular gas process. Which of the following is true: W the work done by the system is:

A) 750 J B) 500 J C) 250 J

D) 450 J E) none of the above




3 A cart of mass 2kg moving at speed +5m/s collides with another stationary cart of mass 3kg on air track (no friction), and the two stick together after the collision. What is their velocity after colliding?

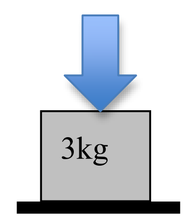
A) 2 m/s B) 1m/s C) -1m/s

D) -2m/s E) none of the above

4 3kg mass rests on the flat surface ($\mu_{stat}$ =0.1) while being acted on by the vertical 10N force as shown. The static friction force acting on this body is equal to:

A 39.4N B 29.4N C 3.94N

D 0N E 2.94 N




5 The race car moving with constant speed of 60m/s around a circular track of radius 1500m. The time (in seconds) of one full lap is equal to :

A $10\pi$ B $30\pi$ C $50\pi$ D$70\pi$ E none of the above

6 In the inelastic collision of two or more particles the following are conserved:

A potential energy B linear momentum C kinetic energy

D all of the above E none of the above

7 Bernoulli's Equation is really another of form of the conservation of

a) Momentum b) Energy c) Volume

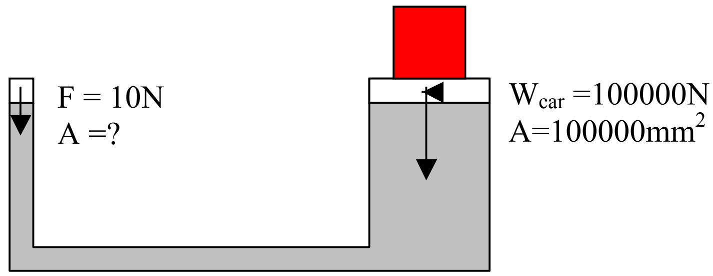
d) Streamlines e) Pressure

8 A 4.0 kg mass starts from rest and is acted on by a constant force. If the mass moves 64 m in 4.0 s, what is the force in N?

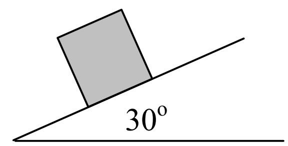
A. 4 B. 8 C. 16 D. 32 E. 64

9 A container is filled with oil and fitted on both ends with pistons. The force acting on the left piston is 10N; that on the right piston is 100000 N .What area must the 10N force act on in the left piston, to keep the 100000N car at the same height?

A $10\ mm^2$
B $100\ mm^2$
C $10000\ mm^2$
D $10^6\ mm^2$
E $10^8\ mm^2$



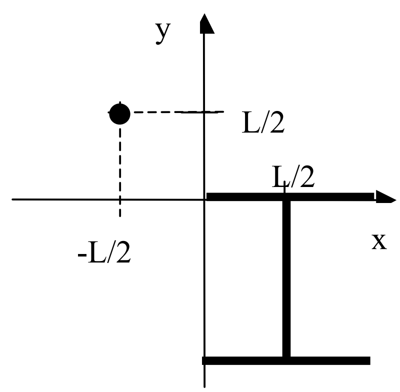

10 Find the force of kinetic friction acting on the 3 kg block sliding with constant velocity down the surface inclined at angle 30 degree to the horizontal.



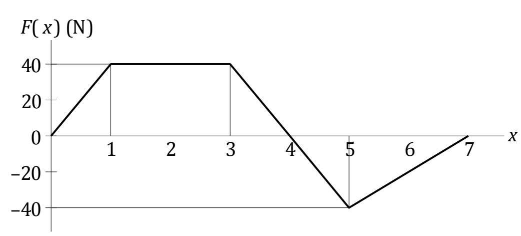

A 25.5N B 14.7N C 29.4 N
D 5.4N E zero

11 Three rods of length L and mass M each, and the particle of mass M, are placed as shown below. The coordinates of the centre of mass of such system are:

A $x_{COM}$ = L/4 $y_{COM}$ = - L/4
B $x_{COM}$ = -L/2 $y_{COM}$ = L/2
C $x_{COM}$ = -L/4 $y_{COM}$ = -L/2
D $x_{COM}$ = -L/4 $y_{COM}$ = L/4
E none of the above




12 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=3m to x=5m ?




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

13 The change of internal energy of gas during the compression of the ideal gas from an initial to a final state

A. depends only on the initial conditions.
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.

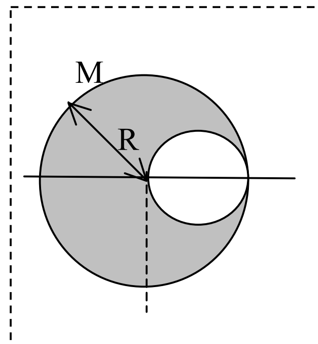
14. A 0.3kg particle moves from the initial position $\mathbf{r}_1$ (3**i**-5**j**-13**k**) m to $\mathbf{r}_2$(3**i**-5**j** +7**k**)m while net force **F**(5**i**-7**j** +3**k**)N is acting on it.
What is the work done by a force on the particle?

A 2.9 J B 40J C 54J D 60J E 64 J

15. A bullet of mass m=20g is fired into a block of mass M = 4kg suspended by a set of two parallel strings. The bullet embeds in the block and raises such pendulum it to a maximum of H= 4cm . The initial velocity (before the collision) of the bullet is:

A 200m/s B 178 m/s C 0.89m/s D 89m/s E 100m/s

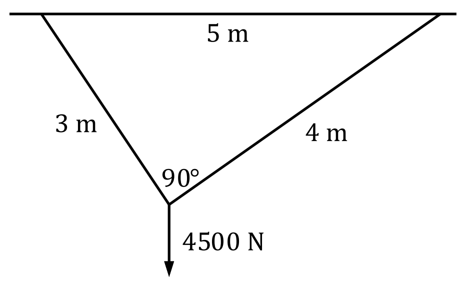
16. **CM** Solid disk of mass M and radius R had the circle of radius R/2 removed. The centre of the hole is R/2 from the centre of the original disk(at x=0). What is the x coordinate of the centre of mass of this object?




A $\frac{1}{6}R$ B $-\frac{1}{6}R$ C $-\frac{1}{3}R$

D $\frac{1}{3}R$ E none of these answers

17. A cable system hanging from a beam is configured as shown in the diagram below. A 4500 N weight hangs from the cables. What is the tension in the 3 m cable in N?
A 2500
B 2700
C 3600
D 3800
E 4200




18. Donna wants to whirl a 0.64 kg stone on a string at the greatest possible speed, but the string will break if a force greater than 24 N is applied. If the maximum speed Donna can achieve is $3.0\ \mathrm{m/s}$, how long should the string be?
A 0.080 m B 0.16 m C 0.24 m D 0.32 m E 0.64 m

19. A balloon filled with hydrogen has a volume of 2.0 $m^3$, when its temperature is 300K and its pressure is 1.0 atm. What volume in $\mathrm{m}^3$ would it have at a pressure of 0.11atm and a temperature of 250 K if R=0.0821l atm/(mol K)?
A) 10 B) 12 C) 13 D) 14 E) 15

20. A 0.500 kg copper cup is at 280 K. If 25kJ of energy is added to it, what is its final temperature in K? The specific heat of copper is $387\ \mathrm{J/kg\cdot°C}$.

A) 389 B) 392 C) 402 D) 409 E) 415

21. The water level in a reservoir is maintained at a constant level. What is the exit velocity in an outlet pipe 3.0 m below the water surface?

A) 2.4 m/s B).0 m/s C) 5.4 m/s D) 7.7 m/s E) 49 m/s

22. Water pressurized to $3.5 \times 10^5$ Pa is flowing at 5.0 m/s in a horizontal pipe which contracts to 1/3 its former area. What are the pressure and velocity of the water after the contraction?

A) $2.5 \times 10^5$ Pa, 15 m/s B) $3.0 \times 10^5$ Pa, 10 m/s

C) $3.0 \times 10^5$ Pa, 15 m/s D) $4.5 \times 10^5$ Pa, 1.5 m/s

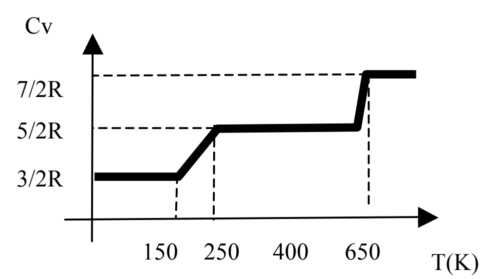
E) $5.5 \times 10^5$ Pa, 1.5 m/s

23 In the ideal gas described by the Boltzmann- Maxwell's distribution of speeds : $N(v_{avg})/N(v_{mp})$ the ratio of number of molecules with the speed equal to $v_{avg}$ to the number of molecules with the speed of $v_{mp}$ is given by the following:

A) $\frac{3}{2}e^2$ B) $\frac{4}{\pi}\frac{e}{e^{\frac{4}{\pi}}}$ C) $\frac{4}{\pi}$ D) $\frac{3}{2}e^{-1}$

E) none of these answers is correct

24 The diagram on the side means that the molecules of real gas represented on it:




A) may rotate but not oscillate for temperatures between 250K and 650K

B) have the heat capacity that does not depend on their internal structure

C) will not rotate and oscillate at the temperatures above 650K

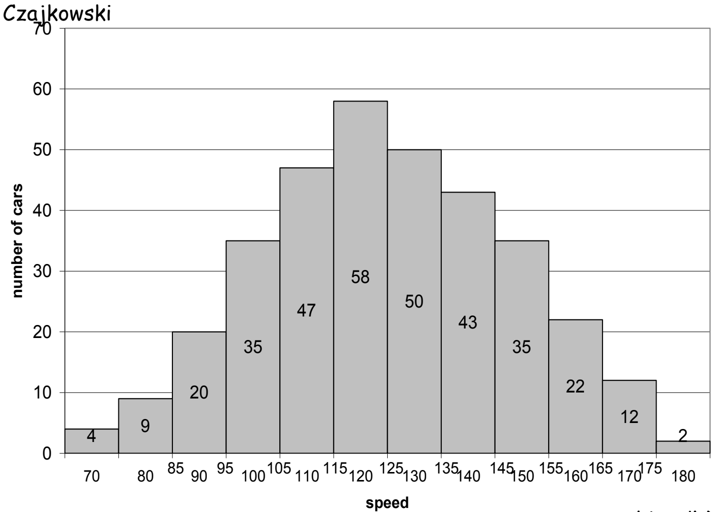
D) may not move in translational motion at temperatures above 650K

E) none of the above

25 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 $0.0305\ \mathrm{kcal/kg\cdot°C}$. $1\ \mathrm{cal} = 4.186\ \mathrm{J}$)

a) $4.21\times10^{-3}$ b) $5.89\times10^{-3}$ c) $4.98\times10^{-3}$ d) $5.25\times10^{-3}$ e) $5.18\times10^{-3}$

26 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 $v_{avg}$ [average speed], and the P (95;115) [probability that the car has speed between 95km/h and 115 km/h) are true:

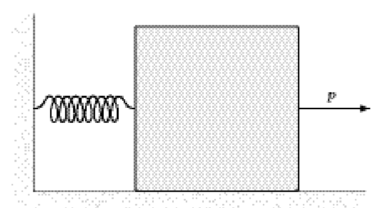



Speed km/h)

a) $v_{avg}$ =127km/h P(95,115) = 0.24
b) $v_{avg}$ =125km/h P(95,115) = 0.16
c) $v_{avg}$ =125km/h P(95,115) = 0.24
d) $v_{avg}$ =127km/h P(95,115) = 0.66
e) none of the above

27 A 12-kg block on a horizontal frictionless surface is attached to 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 3 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



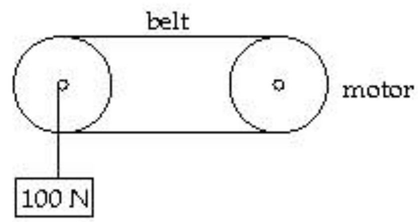

28 In an adiabatic process 16 J of work are done on each mole of a gas. If the gas has 5 degrees of freedom, how much does its temperature change? Answer in terms of R.
A) 40/R (K) B) 11.43/R (K) C) 6.4/R (K)
D) 3.2/R(K) E) none of the above

29 An ideal gas with $\gamma$ = 1.400 expands adiabatically from a pressure of 365.0 Pa and a volume of 70.00 $m^3$, doing 101.0 J of work while expanding to a final volume. What is its final pressure-volume product?
A) 139,600 Pa · $m^3$ B) 139,700 Pa · $m^3$ C) 25,710 Pa · $m^3$
D) 25,510 Pa · $m^3$ E) None of the above

30 A 0.18 m radius pulley is free to rotate about a horizontal axis. A 4.2 kg mass and a 8.0 kg mass are attached by a massless string, which is hung over the pulley. If the string does not slip, calculate the magnitude of the net torque on the pulley about its rotational axis.

A) 5.5 N · m B) 6.7 N · m C) 7.6 N · m D) 9.5 N · m
E) none of the above

31 A winch is being used to raise a 100 N load. If the motor supplies a torque at a radius of 1.4 m and the cylinder upon which the rope is being wrapped has a radius a 0.6 m how much force must the motor supply to keep the load suspended in place while the work crew goes to lunch?




A 230 N
B 80 N
C 70 N
D 43 N
E none of the above

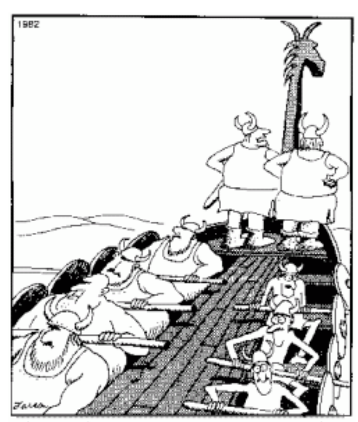
32 A solid, uniform sphere of mass 2.0 kg and radius 1.7 m rolls without slipping down an inclined plane of height 7.0 m. What is the angular velocity of the sphere at the bottom of the inclined plane?

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

33. A uniform beam having a mass of 60 kg and a length of 2.8 m is held in place at its lower end by a pin. Its upper end leans against a vertical frictionless wall.
The beam makes 40-deg angle with the horizontal surface.
What is the magnitude of the force the pin exerts on the beam?

a. 0.68 kN b. 0.57 kN c. 0.74 kN
d. 0.63 kN e. 0.35 kN

That is it! You made it.
Merry Christmas and Happy New Year!
/if you celebrate them!/
All the rest enjoy your holidays!


I've got it, too, Omar... a strange feeling like we've just been going in circles

## Mechanics

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

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

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

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

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

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

$$F_B = \rho_l V.g$$

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

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

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

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

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

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

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

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

Power $P = \tau\omega$

Angular momentum $L = I\omega$

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

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

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# 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:

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

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

$\Delta$Eint = 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 |

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

$$\in_{CRN} = \frac{W}{Q} = \left|\frac{Q_H - Q_L}{Q_H}\right| = 1 - \frac{T_C}{T_H} \qquad \textbf{COP} = \frac{\textbf{what we want}}{\textbf{what we pay for it}}$$

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

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

Q = mc$\Delta$T $\qquad$ Q = Lm

c(water) = 4186 J/(kg C); $\qquad$ c(ice) = 2090 J/(kg C); $\qquad$ 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