Equation Sheet, Phys 1321 (Exam II), University of Houston, Fall 2016

Instructor: Dr. W. P. Su

$\vec{v}(t) = \frac{d\vec{r}(t)}{dt}$

$\vec{v}_{ave} = \frac{\Delta\vec{r}}{\Delta t}$

$\vec{a}(t) = \frac{d\vec{v}(t)}{dt}$

$\vec{a}_{ave} = \frac{\Delta\vec{v}}{\Delta t}$

$Ave.speed = \frac{\text{distance}}{\text{time}}$

$Speed = |\vec{v}|$

If $\vec{a}$ is a constant:

$\vec{v}(t) = \vec{v}_0 + \vec{a}\, t$

$\vec{r}(t) = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}\, t^2$

$v^2{}_x = v^2{}_{0x} + 2a_x\,(x - x_0)$

$\vec{r}(t) = \vec{r}_0 + \frac{(\vec{v}_0 + \vec{v})t}{2}$

Relative Velocity:

$\vec{v}_{p/A} = \vec{v}_{p/B} + \vec{v}_{B/A}$

$a_{rad} = \frac{v^2}{r}$

$a_{tan} = \frac{d|\vec{v}|}{dt}$

$|\vec{a}| = \sqrt{a^2{}_{rad} + a^2{}_{tan}}$

$\sum \vec{F} = \vec{F}_{total} = m\,\vec{a}$

$\sum \vec{p} = m\vec{v}$

$\vec{F}_{total} = \frac{d\vec{p}}{dt}$

$f_s \le \mu_s N$

$f_k = \mu_k N$

$F_g = mg$, $U_g = mgy$

$\vec{F}_{spring} = -kx\hat{\imath}$

$U_{spring} = ½\, kx^2$

$\vec{F} = -\left(\frac{\partial U}{\partial x}\hat{\imath} + \frac{\partial U}{\partial y}\hat{\jmath} + \frac{\partial U}{\partial z}\hat{k}\right)$

$W = \int_{z_i}^{x_f} \vec{F}\,.\,d\vec{r}$

If $\vec{F}$ is constant, $W = \vec{F}\,.\,\vec{r}$

Kinetic energy $K = ½\, mv^2$

$W_{total} = K_2 - K_1 = \Delta K$

$W_{other} = -\Delta U_{int}$

$P_{average} = \frac{W}{\Delta t}$, $P = \frac{dW}{dt}$

If $\vec{F}$ is constant, $P = \vec{F}\,.\,\vec{v}$

Impulse $\vec{J} = \int_{t_1}^{t_2} \vec{F} * dt$

$\vec{J} = \vec{P}_2 - \vec{P}_1$

$\vec{r}_{cm} = \frac{\sum_i m_i \vec{r_i}}{m_{total}}$

$\vec{v}_{cm} = \frac{\sum_i m_i \vec{v}}{m_{total}}$

$\vec{P}_{cm} = \vec{P}_{total} = m_{total}\,\vec{v}_{cm}$

$W_{grav} = Fs = w\,(y_1 - y_2)$

$= mgy_1 - mgy_2$

For an elastic collision with

$v_2 = 0$,

$v_{1f} = \frac{m_1 - m_2}{(m_1 + m_2)}\, v_{1i}$

$v_{2f} = \frac{2m_1}{(m_1 + m_2)}\, v_{1i}$

Circular motion:

$\alpha(t) = \frac{d^2\,\theta(t)}{dt^2}$

$\alpha(t) = \frac{d\,\omega(t)}{dt}$

$\theta = s/r$, $\omega = v/r$, $\alpha = a_{tan}/r$

$\vec{\alpha}(t) = \vec{a}_t(t) + \vec{a}_{rad}(t)$

$|\vec{a}_t(t)| = \alpha(t)r$

$\omega^2{}_f - \omega^2{}_i = 2\alpha\,\theta$

$a_{rad} = \frac{v^2}{r} = \omega^2 r$

$I_{cm} = \sum_i m_i\, r_i{}^2$

Parallel axes theorem: $I = I_{cm} + md^2$

Rotational kinetic energy $K_{rot} = ½\, I\,\omega^2$

I_{cm} of a disk about an axis ⊥ to faces

$= ½\, MR^2$

I_{cm} of a thin rod of length L

about an axis ⊥ to length $= \frac{1}{12}\, ML^2$

$g = 9.8\ m/s^2$

$\vec{A}\cdot\vec{B} = AB\,cos\theta$

$|\vec{A} \times \vec{B}| = AB\,sin\theta$

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

circular motion:

$\vec{a}(t) = \vec{a}_t(t) + \vec{a}_c(t)$

$\vec{a}_c(t) = -\frac{v^2}{r}\hat{r} = -\omega^2 r\hat{r}$

$|\vec{F}_c| = |m\vec{a}_c| = m\frac{v^2}{r} = mr\omega^2$

$\vec{\tau} = \vec{r} \times \vec{F}$

$\vec{\tau} = I\vec{\alpha}$

$\vec{L} = \vec{r} \times \vec{p}$

$\vec{L} = I\vec{\omega}$

$\vec{\tau} = \frac{d\vec{L}}{dt}$

$KE_{rot} = \frac{1}{2} I_{cm} \omega^2$

$\frac{1}{2} I\omega^2 - \frac{1}{2} I\omega_0^2 = \tau(\theta - \theta_0)$

Rolling constraints

$s = R\theta$

$v = R\omega$

$a_t = R\alpha$

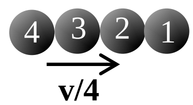
Question Paper
Physics 1321, University of Houston
Exam II, Fall 2016
Instructor: Ed Hungerford

Bubble in your name, seven digit myUH ID#, and your answers on the Scantron. Use a #2 pencil. Unless otherwise noted, ignore air resistance.

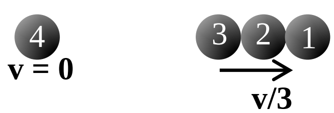
1. Three identical steel balls in contact with each other and resting on a frictionless table are hit head-on by another steel ball of the same mass moving initially with a speed ‘v’.

If the collision is elastic, which of the following is a possible result after collision?

A.


B.


C.


D.


E.


2. If we know that momentum is conserved in a collision between two bodies, we can say

A. that the collision is elastic.

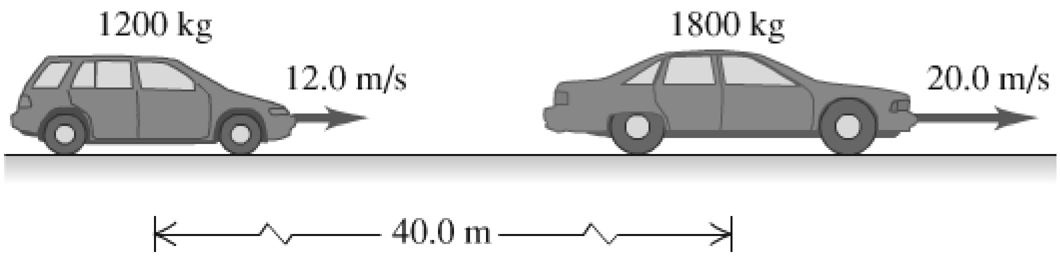
B. that the collision is inelastic.

C. that the collision is completely inelastic.

D. that the collision can be elastic or inelastic, but not completely inelastic.

E. nothing about the nature of collision without additional information.

3. A 1200 kg station wagon is moving along a straight highway at 12.0 m/s. Another car, with mass 1800 kg and speed 20.0 m/s, has its center of mass 40 m ahead of the center of mass of the station wagon (see the figure below). The speed of the center of mass of the system consisting of the two automobiles is ________.



A. 24.1 m/s

B. 16.8 m/s

C. 0 m/s

D. 15.2 m/s

E. non-zero, but we do not have enough information to calculate the velocity of the center of mass of the system.

4. A light and thin string attached to a bucket of mass 3 kg is wrapped around a disk of mass 5 kg and radius 0.6 m (see figure below). Find the speed of bucket after it has fallen 10 m, starting from rest. Assume that the string does not slip as it unwinds.

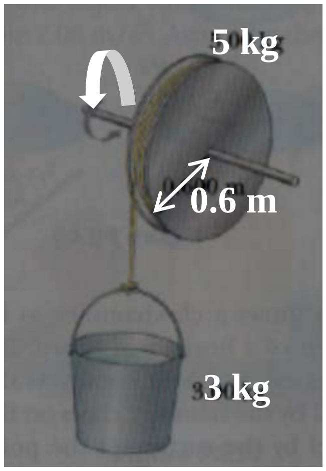
A. 14.0 m/s

B. 8.9 m/s

C. 11.4 m/s

D. 17.1 m/s

E. 10.3 m/s



5. Two identical balls are thrown directly upward, ball A at speed v and ball B at speed 2v, and they feel no air resistance. Which statement about these balls is correct?

A. Ball B will go twice as high as ball A because it had twice the initial speed.

B. Ball B will go four times as high as ball A because it had four times the initial kinetic energy.

C. The balls will reach the same height because they have the same mass and the same acceleration.

D. At its highest point, ball B will have twice as much gravitational potential energy as ball A because it started out moving twice as fast.

E. At their highest point, the acceleration of each ball is instantaneously equal to zero because they stop for an instant.

6. The figure below shows the time dependent variation of a force of magnitude F_x acting in the x-direction on a 2 kg particle. Find the velocity of the particle at 8 seconds, if it is initially at rest.

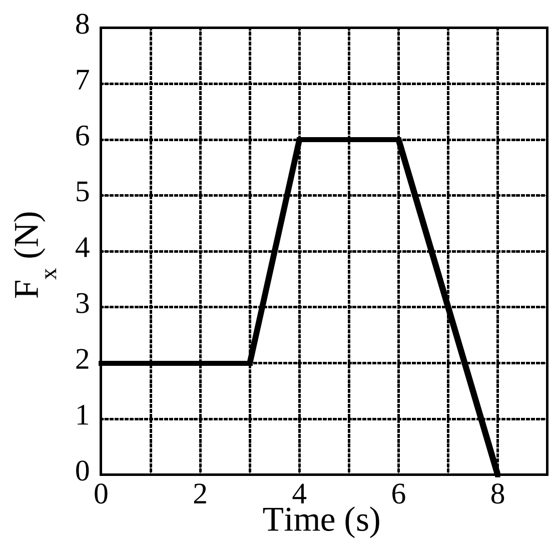
A. 13.5 m/s

B. 14.0 m/s

C. 8.0 m/s

D. 0 m/s

E. 12.5 m/s



7. A traveler pulls on a suitcase strap at an angle of 36^o above the horizontal. If 321 J of work are done by the strap while moving the suitcase a horizontal distance of 15 m, what is the tension in the strap?

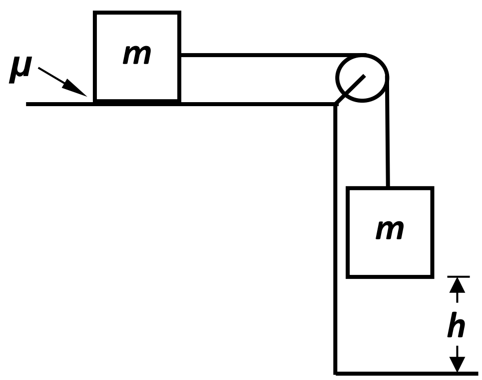
A. 21 N
B. 26 N
C. 29 N
D. 32 N

8. It requires 35 J of work to stretch an ideal very light 1.4 m long spring to a length of 2.9 m. What is the value of the spring constant of this spring?

   A. 31 N/m
   B. 45 N/m
   C. 60 N/m
   D. 89 N/m

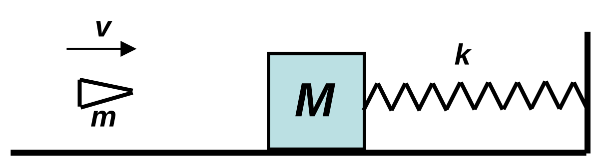
9. A block with mass of 2 kg initially rests on a rough horizontal table top. Then another identical block is hung 1 m above the ground by an ideal string passing through an ideal pulley to connect to the block on the table top. If the kinetic friction coefficient between the block and the rough table top is 0.30, the speed of the hanging block just before hitting the ground is about:

   A. 1.7 m/s
   B. 2.6 m/s
   C. 3.7 m/s
   D. 4.0 m/s
   E. 5.2 m/s

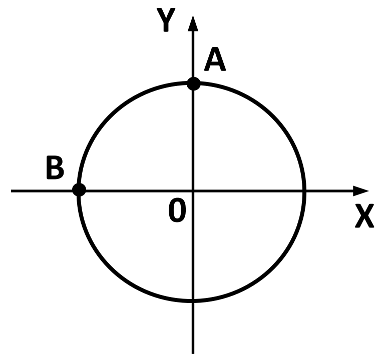


10. Particle 1 of mass *m* moves at a speed of 3*v* in the positive x-direction and particle 2 of mass 2*m* moves at a speed of 2*v* in the negative y direction right before their collision. After the collision, particle 2 stops moving. What is the speed of particle 1 after the collision?
    A. 0
    B. v
    C. 3v
    D. ($\sqrt{17}$)v
    E. 5v

11. As shown in the figure, a block of mass *M*, at rest on a horizontal frictionless table, is attached to a rigid support by a spring of constant *k*. A bullet of mass *m* and velocity of ***v*** strikes and is embedded in the block. How much will the spring be compressed when mass M (with the bullet in it) first comes to a stop?
    A. (m +M) v / $\sqrt{kM}$
    B. m v / $\sqrt{k(m+M)}$
    C. M v / $\sqrt{k(m+M)}$
    D. m v / $\sqrt{kM)}$
    E. (m +M) v / $\sqrt{km}$

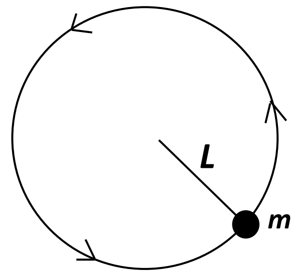


12. A particle moves with constant speed around the circle shown below. When it is at point A its coordinates are x = 0, y = 2 m and its velocity is (- 4 m/s)$\hat{i}$. When it is at point B its velocity and acceleration are:



a. (4 m/s) $\hat{j}$ and (8 m/s^2) $\hat{\imath}$, respectively
b. - (4 m/s) $\hat{j}$ and -(8 m/s^2)$\hat{i}$, respectively
c. (4 m/s)$\hat{i}$ and -(8 m/s^2)$\hat{i}$, respectively
d. - (4 m/s) $\hat{j}$ and (8 m/s^2)$\hat{i}$, respectively
e. (4 m/s) $\hat{j}$ and 0, respectively

13. A ball of mass m, at one end of a string of length *L*, rotates in a vertical circle just fast enough to prevent the string from going slack at the top of the circle. The speed of the ball at the bottom of the circle is:



1. $\sqrt{2gL}$
2. $\sqrt{3gL}$
3. $\sqrt{4gL}$
4. $\sqrt{5gL}$
5. $\sqrt{7gL}$

14. A string is wrapped around a pulley with a radius of 2.0 cm and no appreciable friction in its axle. The pulley is initially not turning. A constant force of 50 N is applied to the string, which does not slip, causing the pulley to rotate and the string to unwind. If the string unwinds 1.2 m in 4.9 s, what is the moment of inertia of the pulley?

A) 0.17 kg • m^2
B) 17 kg • m^2
C) 14 kg • m^2
D) 0.20 kg • m^2
E) 0.017 kg • m^2

Solution Exam 2

1) To conserve momentum in the collision the input momentum, mv_4, must equal the output momentum, mv_1, and $E_{in} \geq E_{out}$. This only occurs for $v_4 = v_1$

The answer is C

2) A collision conserves momentum but not necessarily energy. The best answer is E

3) The center of mass, COM, is located by

$$R = \frac{1}{M}(m_1 R_1 + m_2 R_2) \quad M = m_1 + m_2$$

Differentiate to get velocities

$$V_{com} = \frac{1}{M}(m_1 V_1 + m_2 V_2)$$

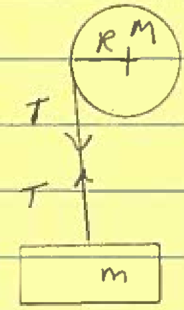
substitute for masses and speeds

$$V = \frac{1}{(1200+1800)}((1200)(12) + (1800)(20))$$

$$V = 16.8 \text{ m/s}$$

The answer is B

4)



Write equations for Pulley and Block

1) $TR = I\alpha = \frac{1}{2}MR^2\alpha = \frac{1}{2}Ma$

2) $T - mg = ma$

Solve equations

$\frac{1}{2}Ma - mg = ma$

$a = \frac{2mg}{M+2m}$

$x = \frac{1}{2}at^2 \rightarrow t = \sqrt{\frac{2x}{a}}$

$t = \sqrt{\frac{2x\,(M+2m)}{2mg}}$

$V = at = \left(\frac{2mg}{M+2m}\right)\sqrt{\frac{x\,(M-2m)}{mg}}$

$V = 2\sqrt{\frac{mgx}{M+2m}}$

Substitute for masses and position

$V = 10.3\ m/s$

the answer is E

5) Initial Kinetic Energy = Potential Energy

$\frac{1}{2}mV^2 = mgh$

Choose $V = V_1$ and $V = 2V_1$

The answer is B

6) $F = ma \quad V = V_0 + at$

movement | Velocity

1) $a = F/m = 2/2 = 1$ | $V = 2+1 = 3$

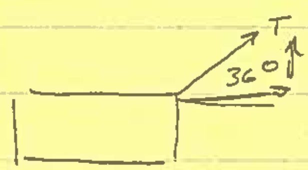
2) $\langle F \rangle = \frac{(2+6)}{2} \quad a = 4/2$ | $V = 3+2(1) = 5$

3) $a = 6/2$ | $V = 5+3(2) = 11$

4) $\langle F \rangle = 3/2$ | $V = 11+(1.5)(2) = 14$

The answer is B

7)



$F_{\parallel} = T\cos(36°)$

$W = F_{\parallel} \cdot d = [T\cos(36°)]\,15$

substitute for W to get $T = 26N$

Answer B

8) The potential energy is

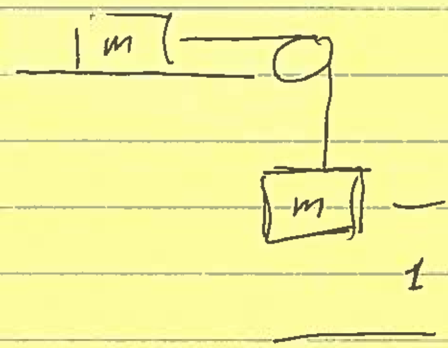
$$P.E. = \frac{1}{2} kx^2$$

Substitute numbers to get

$$k = \frac{(2)(35)}{(2.9)(1.4)} = 31 \, N/m$$

Answer A

9)



use Energy conservation

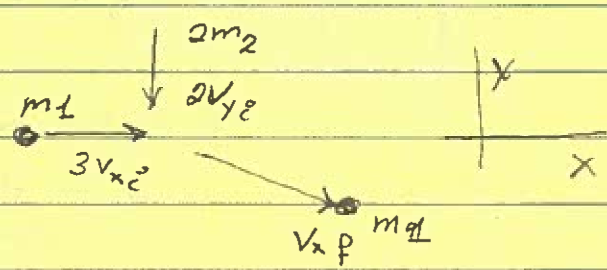
$$mgh = (\tfrac{1}{2} mv^2)(\tfrac{1}{2} mv^2) - \mu mg$$

$$(2)(9.81)(1) = 2(\tfrac{1}{2}(2) V^2) + (0.3)(2)(9.81)$$

$$V = 2.6$$

Answer (B)

10)



Conserve momentum in the x and y directions

$$m_1 V_{x_i} = m_1 V_{xf}$$

$$2 m_1 V_{y_i} = m_1 V_{yf}$$

$$V_{yf} = 2V_{yi} = 4V$$

$$V_{xf} = V_{xi} = 3V$$

Answer E

$$V_f = \left[V_{xf}^2 + V_{yf}^2 \right]^{1/2}$$

11)

Initial momentum Final moment

mV $(m+M)V_f$

$KE_{final} = \frac{1}{2}(m+M)V_f^2 = \frac{1}{2}kx^2$

$mV = (m+M)\left(\frac{kx^2}{(m+M)}\right)^{1/2}$

$\frac{mv}{\sqrt{(m+m)\,k}}$

Answer B

12) $v = -4\,m/s\; i$

$B = -4\,m/s\; i + \frac{v^2}{r}\, x$

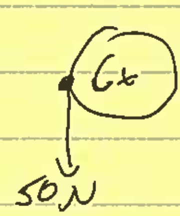
Answer D

13) at the top $\frac{v^2}{L} = g$

$mgh = 2mgL + \frac{1}{2}mgL$

Answer 4

14)



$\tau = I\alpha = (50)(.02) = 1$

$\theta = \frac{1}{2}\alpha t^2$ $R\theta = 1.2m$

$\frac{(1.2)(1/2)}{(4.9)^2} = \alpha$ $\alpha = 5$

Answer D