Final Exam
in B115 WELLS HALL

Seat assignments on the course Website

Topics not covered in this review
Ch. 1 required: units, v = d/t , moles, areas, vol., [M] [T] [L], trig., density
Ch. 2

59. ■ You're driving at 50 km/h, when the traffic light 40 m away turns yellow. Find (a) the constant acceleration required to stop at the light and (b) the stopping time. Is the acceleration reasonable?

$v_0 = +50\times10^3\,\text{m} / 3600\,\text{s} = +13.89\,\text{m/s}$

$\Delta x = +40\,\text{m}$ Note: no time given, a is constant.

a) $a = \dfrac{v^2 - v_0^2}{2\Delta x} = \dfrac{0-(13.89)^2}{2(40)}\,\text{m/s}^2 = -2.41\,\text{m/s}^2 \rightarrow \underline{-2.4\,\text{m/s}^2}$ 2 sig. figs.

b) $t = \dfrac{v - v_0}{a} = \dfrac{0-(13.89\,\text{m/s})}{-2.41\,\text{m/s}^2} = 5.76\,\text{s} \rightarrow \underline{5.8\,\text{s}}$

Ch. 2 (really Ch. 3)

81. ■■■ A world-class volleyball player can jump vertically 1.1 m from a standing start. (a) How long is the player in the air? (b) Graph the athlete's position versus time. (c) Use your graph to explain why an athlete might appear to "hang" in the air near the top of the jump.

Given: $a = -g = -9.81\,\text{m/s}^2$, when $\Delta y = +1.1\,\text{m}$

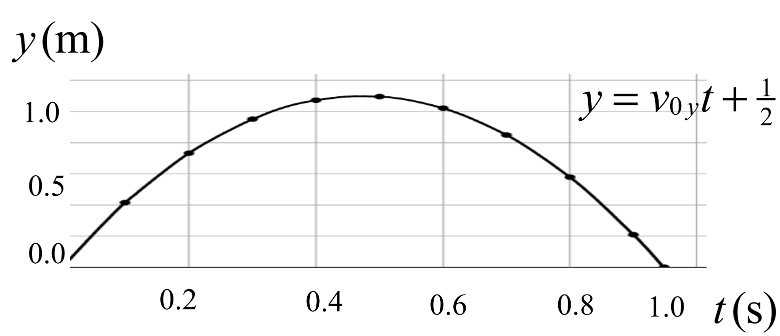
Note: no v_{y0} or t, but $v_y = 0$.

Plan: first find v_{y0}: $v_y^2 = v_{y0}^2 + 2a\Delta y = 0$

$$v_y = 0: \qquad v_{y0} = \sqrt{-2a\Delta y} = \sqrt{(9.81)(2.2)}\,\text{m/s} = 4.64\,\text{m/s}$$

Up & Down: $\Delta y' = 0$: $\Delta y' = v_{0y}t' + \tfrac{1}{2}at'^2 = 0$

$$t' = \frac{-2v_{0y}}{-g} = \frac{2(4.64\,\text{m/s})}{9.81} = \underline{0.95\,\text{s}}$$



$y = v_{0y}t + \tfrac{1}{2}at^2$

Ch. 3

67. ■■■ A projectile is fired horizontally at 13.4 m/s from the edge of a 9.50-m-high cliff and strikes the ground. Find (a) the horizontal distance it traveled; (b) the elapsed time; and (c) its final velocity.

Given: $v_x = v_{x0} = 13.4\,\text{m/s},\ \ a_x = 0$

$$: v_{y0} = 0,\ \ \Delta y = -9.50\,\text{m},\ \ a_y = -g = -9.81\,\text{m/s}^2$$

$$\Delta y = t + \tfrac{1}{2} a_y t^2 \quad \rightarrow t = \sqrt{\frac{2\Delta y}{a_y}} = \sqrt{\frac{-19.0}{-9.81}} = \underline{1.39\,\text{s}}$$

$$\Delta x = v_{x0} t = (13.4)1.39\,\text{m} = \underline{18.6\,\text{m}}$$

$$v_y = v_{y0} + a_y t$$

$$= 0 + (-9.81)(1.39)\,\text{m/s}$$

$$= -13.6\,\text{m/s}$$

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(13.4)^2 + (-13.6)^2} = \underline{19.3\,\text{m/s}}$$

$$\theta = \tan^{-1}(v_y / v_x) = \tan^{-1}(-13.6\,\text{m/s} / 13.4\,\text{m/s}) = \underline{-45.4°}$$

Ch. 4

63. ■■■ Three blocks of mass m_1, m_2, and m_3 are touching on a frictionless horizontal surface, and a 36-N horizontal force is applied, as shown in Figure P4.63. (a) Find the acceleration of the blocks. (b) Find the net force on each block. (c) With what force does each block push on the one in front of it?

FIGURE P4.62

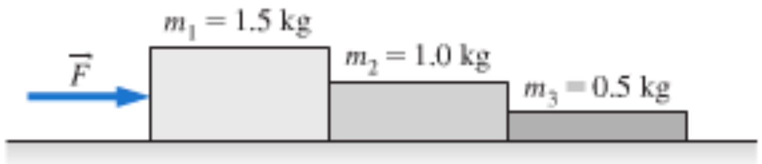


FIGURE P4.63

Given: $\vec{F} = +36\,\text{N}$, $m_1 = 1.5\,\text{kg}$, $m_2 = 1.0\,\text{kg}$, $m_3 = 0.5\,\text{kg}$

$m = m_1 + m_2 + m_3 = 3.0\,\text{kg}$

a) $\vec{a} = \dfrac{\vec{F}}{m} = \dfrac{36}{3.0}\,\text{m/s}^2 = \underline{+12\,\text{m/s}^2}$ (the same for all masses)

b) $\vec{F}_1 = m_1 a = 1.5(12)\,\text{N} = +\underline{18\,\text{N}},$ (Net force on m_1)

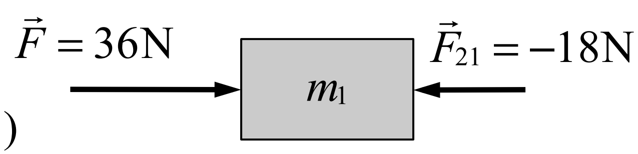
$\vec{F}_2 = m_2 a = +\underline{12\,\text{N}},$ (Net force on m_2)

$\vec{F}_3 = m_2 a = \underline{+6\,\text{N}}$ (Net force on m_3)

c) $\vec{F}_1 = \vec{F} + \vec{F}_{21}$ ($\vec{F}_{21}$ is force of m_2 on m_1)

$\vec{F}_{21} = \vec{F}_1 - \vec{F} = (18 - 36)\,\text{N} = -18\,\text{N}$ (m_2 pushing on m_1)

$\vec{F}_{12} = -\vec{F}_{21}$(3rd Law) $\underline{\vec{F}_{12} = +18\,\text{N}}$ (m_1 pushing on m_2)



$\vec{F}_1 = m_1 a = +\underline{18\,\text{N}}$

Also, $\vec{F}_{32} = -\vec{F}_{23} = -\vec{F}_3$ (m_3 pushing on m_2)

$= \underline{-6\,\text{N}}$

Ch. 5

93. ■■■ A spring with $k = 42.0\ \text{N/m}$ is mounted horizontally at the edge of a 1.20-m-high table (Figure P5.93). The spring is compressed 5.00 cm, and a 25.0-g pellet is placed at its end. When the spring is released, how far (horizontally) from the edge of the table does the pellet strike the floor?

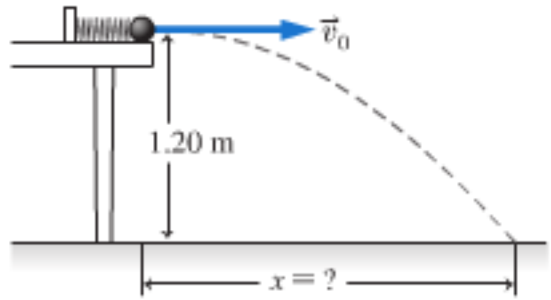


FIGURE P5.93

Given: $k = 42\,\text{N/m},\ x = 0.05\text{m},\ m = 0.025\text{kg},\ K_1 = 0$

Analyze 2 steps: fire projectile, then it falls, $\Delta y = 1.2\text{m}$

$$U_S = \tfrac{1}{2}kx^2 = (0.5)(42)(0.05)^2 = 5.25\times10^{-2}\,\text{J}$$

$$E_1 = U_1 + K_1 = 5.25\times10^{-2}\,\text{J} \qquad \text{(before firing, } U_1 = U_S, K_1 = 0\text{)}$$

$$E_2 = U_2 + K_2 = K_2 \qquad \text{(after firing, } U_2 = 0\text{)}$$

Energy conserved: $E_2 = E_1 \quad \rightarrow K_2 = 5.25\times10^{-2}\,\text{J} = \tfrac{1}{2}mv^2, \quad v = v_{x0}$

$$v_{x0} = \sqrt{\frac{2K_2}{m}} = \sqrt{\frac{2(5.25\times10^{-2})}{0.025}}\,\text{m/s} = 2.05\text{m/s}$$

Step 2 mass falls: $t = \sqrt{\dfrac{2\Delta y}{g}} = 0.495\ \text{s}$

$$\Delta x = v_{x0}t = (2.05)(0.495)\text{m} = \underline{1.01\text{m}}$$

Ch. 6

61. ■ A 60.0-kg ice skater moving at 1.85 m/s in the $+x$-direction collides elastically with an 87.5-kg skater initially at rest. Find the velocities of the two skaters after the collision.

Momentum Conservation for x-components: $m_1 v_1 = m_1 v_1' + m_2 v_2'$

Energy Conservation for x-components: $\frac{1}{2} m_1 v_1^2 = \frac{1}{2} m_1 v_1'^2 + m_2 v_2'^2$

Solving for v_1' and v_2' gives: (see page 141 Summary)

$$v_1' = \frac{m_1 - m_2}{m_1 + m_2} v_1 = \frac{60 - 87.5}{60 + 87.5}(+1.85\,\text{m/s}) = \underline{-0.35\,\text{m/s}} \text{ (recoils backward)}$$

$$v_2' = \frac{2m_1}{m_1 + m_2} v_1 = \frac{120}{147.5}(+1.85\,\text{m/s}) = \underline{+1.51\,\text{m/s}} \text{ (goes forward)}$$

Also should look at completely INELASTIC collisions where masses stick together.

Ch. 7

64. ■■■ A puck with mass 0.16 kg slides along a frictionless horizontal surface at 5.5 m/s. It hits and sticks to the free end of a spring with $k = 15$ N/m (Figure P7.64). Find the amplitude and period of the subsequent simple harmonic motion.

FIGURE P7.64

The end of the spring is at $x = 0$ (the equilibrium position)

It is where the speed of the mass will be a maximum.

$k = 15\text{N/m},\ m = 0.16\text{kg}$ and $\omega = \sqrt{k/m} = \sqrt{15/0.16}\,\text{rad/s} = 9.68\,\text{rad/s}$

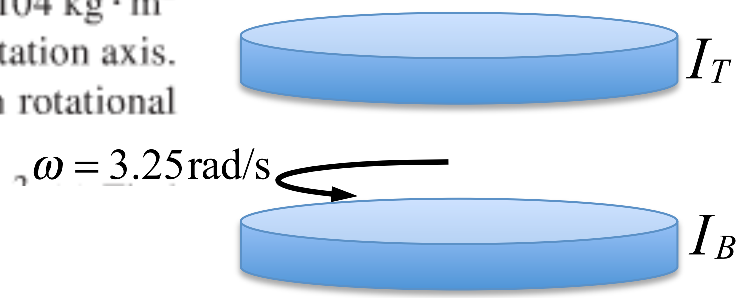
$K = \frac{1}{2}mv^2 = 0.5(0.16)(5.5)^2\,\text{J} = 2.42\ \text{J}$

$U_{S(\max)} = \frac{1}{2}kA^2 = 2.42\ \text{J} \quad \rightarrow A = \sqrt{\frac{2(2.42)}{15}} = \underline{0.57\,\text{m}}$

$$T = \frac{1}{f} = \frac{1}{\omega/2\pi} = \underline{0.65\text{s}}$$

Ch. 8

89. ■■ A turntable with a rotational inertia $0.225 \text{ kg}\cdot\text{m}^2$ is rotating at 3.25 rad/s. Suddenly, a disk with rotational inertia $0.104 \text{ kg}\cdot\text{m}^2$ is dropped onto the turntable with its center on the rotation axis. Assuming no outside forces act, what's the common rotational velocity of the turntable and disk?



No external torques $\rightarrow$ Angular momentum conserved

Starting angular momentum $L_1 = I_B \omega_B$,

Ending angular momentum $L_2 = I_2 \omega_2$,

Ending rotational inertia $I_2 = I_B + I_T$

$$I_2 = (0.225 + 0.104)\text{kg}\cdot\text{m}^2 = 0.329\text{kg}\cdot\text{m}^2$$

Angular momentum conservation

$L_1 = L_2 \quad \rightarrow I_B \omega_B = I_2 \omega_2$

$$\omega_2 = \frac{I_B}{I_2}\omega_B = \frac{0.225}{0.329}(3.25 \text{ rad/s}) = 2.22 \text{rad/s}$$

62. ■■■ Two identical asteroids, each with mass M and radius R, are released from rest a large distance apart. They're attracted by their mutual gravitation and eventually collide. (a) Use conservation of energy to find the speed v of each asteroid just before the collision. (b) Evaluate numerically, assuming the asteroids each have mass 2.0×10^{13} kg and radius 1.0 km.

Asteroids start very far apart with no relative speed.

The total energy to start is zero.

The total energy just before collision must also be zero.

r is separation of the asteriods , r is $2R$ at collision.

$$E = 2K_A + U_{AA} = mv^2 - \frac{Gm^2}{r} = 0$$

$$v = \sqrt{\frac{Gm}{2R}} = \sqrt{\frac{(6.67\times10^{-11})(2.0\times10^{13})}{2000}}\ \text{m/s} = 0.82\,\text{m/s}$$

Ch. 10

45. BIO ■■ **Blood transfusion.** During a transfusion, it's best for the pressure of the incoming blood to be equal to the body's diastolic pressure. If that's 70 mm Hg, how high above the insertion point should the blood supply be placed? See Table 10.1 for blood's density.

$$\rho_{Hg} = 13{,}600 \text{ kg/m}^3,\ \rho_{blood} = 1{,}060 \text{ kg/m}^3,\ h_{Hg} = 70 \text{mm of Hg}$$

$$\Delta P = \rho_{Hg} g h_{Hg} = (13{,}600)(9.81)(0.070) = 9.34 \times 10^3 \text{ N/m}^2$$

$$h_{blood} = \frac{\Delta P}{\rho_{blood} g}$$

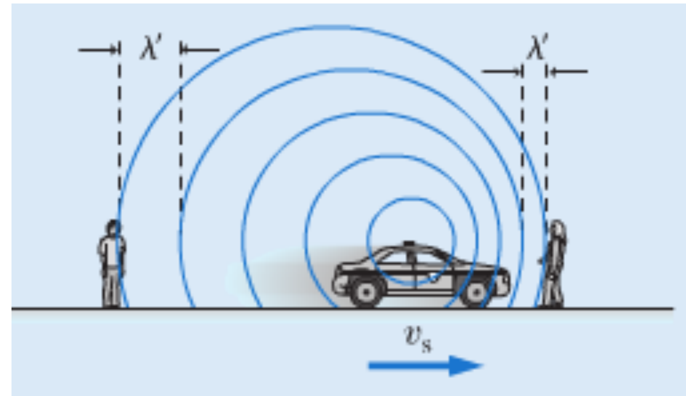
$$= \frac{\rho_{Hg} g h_{Hg}}{\rho_{blood} g} = \frac{\rho_{Hg}}{\rho_{blood}} h_{Hg} = \frac{13{,}600}{1{,}060}(0.070) = \underline{0.90 \text{m}}$$

ıon Solids, Liquids, and Gases

Material	Density (kg/m^3)
Liquids	
Gasoline	680
Ethanol	790
Benzene	900
Oil (typical)	
Water (fresh)	1000
Seawater	1030
Blood	1060
Mercury	13,600

Ch. 11

77. ■■ A jet is flying at 99% the speed of sound, its engines emitting a 1200-Hz tone. Find the frequency and wavelength of the tone you hear when the jet is flying (a) toward you and (b) away from you.



Sound speed $v = 343\,\text{m/s}$ but not needed!

Approaching: $f' = \dfrac{f}{1 - v_s/v} = \dfrac{1200\,\text{Hz}}{1 - 0.99} = 120{,}000\,\text{Hz}$

Receding: $f' = \dfrac{f}{1 + v_s/v} = \dfrac{1200\,\text{Hz}}{1 + 0.99} = 600\,\text{Hz}$

Source approaching: $f' = \dfrac{f}{1 - v_s/v}$

Source receding: $f' = \dfrac{f}{1 + v_s/v}$

70. Venus's atmosphere is mostly CO_2. If the rms speed of a carbon dioxide molecule at Venus's surface is 652 m/s, what's the temperature there?

$$k = 1.38\times10^{-23}\ \text{J/K},\quad R = 8.31\ \text{J/K}\cdot\text{mol}$$

$$v = 652\,\text{m/s}$$

molar mass: $u_{CO_2} = (12+32)\text{g} = 44\times10^{-3}\text{kg}$

molecular mass: $m_{CO_2} = \dfrac{u_{CO_2}}{N_A} = \dfrac{44\times10^{-3}\text{kg}}{6.02\times10^{23}} = 7.31\times10^{-26}\ \text{kg}$

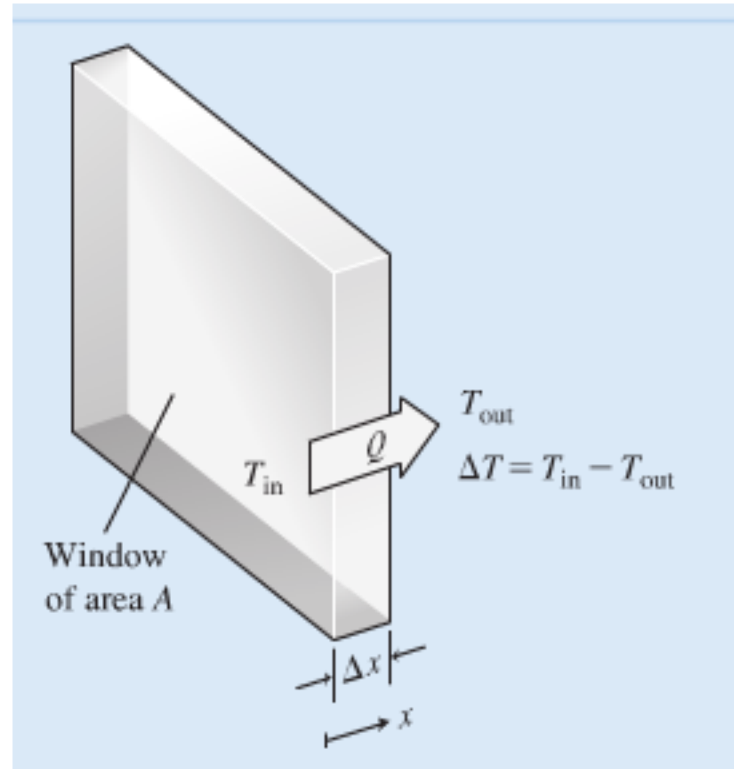
$$K = \tfrac{1}{2}mv^2 = \tfrac{3}{2}kT$$

$$T = \frac{mv^2}{3k} = \frac{7.31\times10^{-26}(652)^2}{3(1.38\times10^{-23}}\text{K}$$

$$= \underline{750\,\text{K}}$$

Ch. 13 76. ■■■ A window with area 1.7 m^2 is made from a single pane of 3.2-mm-thick glass. (a) If it's 15°C colder outdoors than inside, what's the heat-flow rate through the window? (b) Repeat for a double-pane window made from the same glass, with a 1.0-mm air gap between the panes.

Substance	Thermal conductivity k (W/(°C·m))
Glass (common)	0.80
Air	0.026



Assume outer glass is at exterior temperature.

Assume inner glass is at room temperature.

Approximate answer use just air gap

$$\Delta x_A = 1.0\times10^{-3}\text{m},\quad k_A = 0.026,\quad A = 1.7\text{m}^2,\quad \Delta T_A = 15°\text{C}$$

$$\frac{Q_A}{t} = k_A A\frac{\Delta T_A}{\Delta x_A} = (0.026)(1.7)\frac{15}{1.0\times10^{-3}\text{m}}\ \text{W (W=J/s)}$$

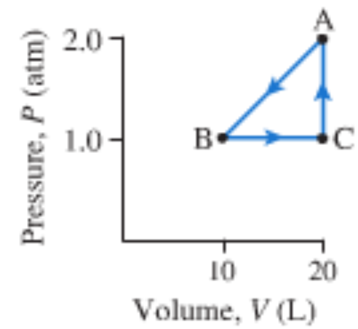
$$= 660\text{W}\quad \text{(actual value is 550W)}$$

Thermal conductivity: $\frac{Q}{t} = kA\frac{\Delta T}{\Delta x}$

Stefan-Boltzmann law: $P = e\sigma AT^4$

Ch. 14

50. ■■■ Consider the three-step cycle described by the complete triangle in Figure P14.49. (a) Is the net work done over the cycle positive or negative? Why? (b) Find the net work.



Work on gas is always (±) area under transition curve in a PV diagram

+ for compression, − for expansion

Process	Work W	First law accounting, with $\Delta U = Q + W$
Constant pressure	$W = -P\Delta V$	$\Delta U = Q - P\Delta V$
Constant temperature (isothermal)	$W = nRT \ln\left(\frac{V_i}{V_f}\right)$	$\Delta U = 0$; $Q = -W = -nRT\ln\left(\frac{V_i}{V_f}\right)$
Constant volume	$W = 0$	$\Delta U = Q$
Adiabatic ($Q = 0$)	$W = \frac{P_f V_f - P_i V_i}{\gamma - 1}$	$\Delta U = W = \frac{P_f V_f - P_i V_i}{\gamma - 1}$

Path: Cycle $A \to B \to C \to A$, $\quad C \to A$ (volume doesn't change $W_{CA} = 0$)

$$W_{Cycle} = W_{AB} + W_{BC} \qquad (W_{AB} = A_{AB},\ \ W_{BC} = -A_{BC})$$

$$A_{AB} = P_A \Delta V_{BC} - \tfrac{1}{2} P_B \Delta V_{BC} = \left[(2.0)(10) - (0.5)(1.0)(10)\right]\ \text{L}\cdot\text{atm} = 15\ \text{L}\cdot\text{atm}$$

$$A_{BC} = P_B \Delta V_{BC} = (1.0)(10)\ \text{L}\cdot\text{atm} = 10\ \text{L}\cdot\text{atm}$$

$$W_{Cycle} = W_{AB} + W_{BC} = A_{AB} + (-A_{BC}) = (15.0 - 10.0)\,\text{L}\cdot\text{atm} = 5.0\,\text{L}\cdot\text{atm}$$

$$= (5.0)(1\times 10^{-3}\,\text{m}^3)(1\times 10^5\,\text{N/m}^2) = \underline{500\,\text{J}}$$

Final Exam
in B115 WELLS HALL

Seat assignments on the course Website