Fall 2009 RED barcode here

Physics 105, sections 1 and 2

Exam 1 Please write your CID_____

Colton 2-3669

No time limit. No notes. No books. Testing Center calculators only. All problems equal weight, 60 points total.

Constants:

$g = 9.8$ m/s^2 → **but you may use 10 m/s^2 in nearly all cases**

$G = 6.67 \times 10^{-11}$ N·m^2/kg^2

$k_B = 1.381 \times 10^{-23}$ J/K

$N_A = 6.022 \times 10^{23}$

$R = k_B \cdot N_A = 8.314$ J/mol·K

$\sigma = 5.67 \times 10^{-8}$ W/m^2·K^4

Mass of Sun = 1.991×10^{30} kg

Mass of Earth = 5.98×10^{24} kg

Radius of Earth = 6.38×10^6 m

Radius of Earth's orbit = 1.496×10^{11} m

Density of water: 1000 kg/m^3

Density of air: 1.29 kg/m^3

Young's modulus of steel: 20×10^{10} N/m^2

Linear exp. coeff. of copper: 17×10^{-6} /°C

Linear exp. coeff. of steel: 11×10^{-6} /°C

Specific heat of water: 4186 J/kg·°C

Specific heat of ice: 2090 J/kg·°C

Specific heat of steam: 2010 J/kg·°C

Specific heat of aluminum: 900 J/kg·°C

Latent heat of melting (water): 33×10^5 J/kg

Latent heat of boiling (water): 2.26×10^6 J/kg

Thermal conduct. of aluminum: 238 J/s·m·°C

$\sin(30°) = 0.5$

$\cos(30°) \approx 0.866$

$\tan(30°) \approx 0.577$

$\pi \approx 3.14$

Conversion factors

1 inch = 2.54 cm

1 m^3 = 1000 L

1 atm = 1.013×10^5 Pa = 14.7 psi

$T_F = \frac{9}{5}T_C + 32$

$T_K = T_C + 273.15$

Other equations

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

Surface area of sphere = $4\pi r^2$

Volume of sphere = $(4/3)\pi r^3$

$$v_{ave} = \frac{v_i + v_f}{2}$$

$$v = v_o + at$$

$$x = x_o + v_o t + \frac{1}{2}at^2$$

$$v_f^{\,2} = v_o^{\,2} + 2a\Delta x$$

$w = mg$, $PE_g = mgy$

$F = -kx$, $PE_s = ½ kx^2$

$f = \mu_k N$ (or $f \le \mu_S N$)

$P = F_{//} \cdot v = Fv\cos\theta$

$F\Delta t = \Delta p$

Elastic: $(v_1 - v_2)_{\text{bef}} = (v_2 - v_1)_{\text{after}}$

arc length: $s = r\theta$

$v = r\omega$

$a_{tan} = r\alpha$

$a_c = v^2/r$

$$F_g = \frac{GMm}{r^2},\ PE_g = -\frac{GMm}{r}$$

$I_{\text{pt mass}} = mR^2$

$I_{\text{sphere}} = (2/5)\, mR^2$

$I_{\text{hoop}} = mR^2$

$I_{\text{disk}} = (1/2)\, mR^2$

I_{rod} (center) = (1/12) mL^2

I_{rod} (end) = (1/3) mL^2

$$L = r_\perp p = rp_\perp = rp\sin\theta$$

stress = F/A; strain = $\Delta L/L$

Y = stress/strain

$$P = P_0 + \rho gh$$

$$VFR = A_1 v_1 = A_2 v_2$$

$$P_1 + \frac{1}{2}\rho v_1^{\,2} + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^{\,2} + \rho g y_2$$

$$\Delta L = \alpha L_0 \Delta T$$

$$\Delta V = \beta V_0 \Delta T;\ \beta = 3\alpha$$

$$KE_{ave} = \frac{1}{2}mv_{ave}^{\,2} = \frac{3}{2}k_B T$$

$$Q = mc\Delta T;\ Q = mL$$

$$\frac{\Delta Q}{\Delta T} = kA\frac{T_2 - T_1}{L}$$

$$P = e\sigma AT^4$$

$|W_{on\ gas}|$ = area under P-V curve

= $P\Delta V$ (constant pressure)

$U = \frac{3}{2}Nk_B T = \frac{3}{2}nRT$ (monatomic ideal gas)

$Q_h = |W_{net}| + Q_c$

$$e = \frac{|W_{net}|}{Q_{added}} = 1 - \frac{Q_c}{Q_h}$$

$$e_{\max} = 1 - \frac{T_c}{T_h}$$

$$\omega = \sqrt{\frac{k}{m}},\ T = 2\pi\sqrt{\frac{m}{k}}$$

$$\omega = \sqrt{\frac{g}{L}},\ T = 2\pi\sqrt{\frac{L}{g}}$$

$$v = \sqrt{\frac{T}{\mu}},\ \mu = m/L$$

$$v = \sqrt{\frac{Y}{\rho}},\ v = \sqrt{\frac{B}{\rho}}$$

v_{air} = 343 m/s at 20° C

$$\beta = 10\log\left(\frac{I}{I_0}\right) \quad I_0 = 10^{-12}\ \text{W/m}^2$$

$$f' = f\,\frac{v \pm v_0}{v \pm v_S}$$

$$f_n = n\frac{v}{2L} \quad n = 1,2,3,...$$

$$f_n = n\frac{v}{4L} \quad n = 1,3,5,...$$

Write your work on the exam pages if you wish. Of course also **record your final answers on the bubble sheet**. You will likely not get this exam booklet back, but please put your CID at the top of this page just in case.

In all problems, **ignore air resistance** unless specifically stated otherwise.
Use g = 9.8 m/s^2 only if there are "9.8" numbers in the answer choices; **otherwise use g = 10 m/s^2.**

Problem 1. Suppose your hair grows at a rate of 0.03 inches per day. How fast does it grow in nanometers per second? ("nano" = 10^{-9})

a. $\dfrac{0.03\times 2.54}{100\times 24\times 60\times 60\times 10^9}$

b. $\dfrac{0.03\times 2.54\times 100\times 10^9}{24\times 60\times 60}$

c. $\dfrac{0.03\times 2.54\times 10^9}{100\times 24\times 60\times 60}$

d. $\dfrac{0.03\times 10^9}{2.54\times 100\times 24\times 60\times 60}$

e. $\dfrac{0.03\times 10^9\times 24\times 60\times 60}{2.54\times 100}$

f. $\dfrac{0.03\times 10^9\times 60\times 60}{2.54\times 100\times 24}$

g. $\dfrac{100\times 2.54\times 10^9}{0.03\times 24\times 60\times 60}$

Problem 2. In a certain right triangle, the two sides that are perpendicular to each other are 4.8 cm and 3.5 cm long. What is the angle for which 4.8 cm is the opposite side?

a. $\sin\left(\dfrac{3.5}{4.8}\right)$

b. $\sin\left(\dfrac{4.8}{3.5}\right)$

c. $\sin^{-1}\left(\dfrac{3.5}{4.8}\right)$

d. $\sin^{-1}\left(\dfrac{4.8}{3.5}\right)$

e. $\tan\left(\dfrac{3.5}{4.8}\right)$

f. $\tan\left(\dfrac{4.8}{3.5}\right)$

g. $\tan^{-1}\left(\dfrac{3.5}{4.8}\right)$

h. $\tan^{-1}\left(\dfrac{4.8}{3.5}\right)$

Problem 3. Joshua throws a stone upward and forward from a cliff. While the stone is still rising, where does the stone's acceleration vector point?

a. down
b. down and backward
c. down and forward
d. up
e. up and backward
f. up and forward

Problem 4. Sally throws a ball upwards at a 10° angle from the horizontal. Her twin sister Susie throws a similar ball at the same time with the same speed, but upwards at a 20° angle. Whose ball hits the ground first?

a. Sally's
b. Susie's
c. They hit at the same time

Problem 5. The "Milkdrop demo" done in class used a strobe camera to look at the instantaneous position of drops that started falling at equally spaced times. Consider the strobe picture just as a drop is leaving the nozzle, with several drops below that drop. What pattern did the *separations* between drops demonstrate? (x is the separation distance between the top two drops.)

a. The separations increased like ratios of the integers: x, $2x$, $3x$, …
b. The separations increased like ratios of the odd integers: x, $3x$, $5x$, …
c. The separations increased like ratios of squared integers: x, $4x$, $9x$, $16x$, …
d. The separations increased like ratios of cubed integers: x, $8x$, $27x$, $81x$, …

Problem 6. Samantha's car accelerates at 0.7 g's. That is, $a = 0.7 \times g$. How long will it take her to go from 20 m/s (44.7 mph) to 34 m/s (76.1 mph)?

a. Less than 0.7 s
b. 0.7 – 1.2
c. 1.2 – 1.7
d. 1.7 – 2.2
e. 2.2 – 2.7
f. 2.7 – 3.2
g. More than 3.2 s

Problem 7. Raul is driving a car at 30 m/s (67.1 mph). He slams on his breaks and decelerates at a rate of 0.9 g's. (That is, $a = -0.9 \times g$.) How far will the car travel before stopping?

a. Less than 43 m (there was a typo; this was given in feet)
b. 43 – 49
c. 49 – 55
d. 55 – 61
e. 61 – 67
f. 67 – 73
g. More than 73 m

Problem 8. Frida throws a ball upwards. Which of the following is the best answer to the question, "Does the ball have some upwards acceleration in the air *after* it leaves her hand?"

a. No, because the air prevents the ball from rising upwards very far.
b. No, because the only acceleration at that point is from gravity.
c. No, because the ball has no acceleration until the top of its path.
d. Yes, because gravity takes over only after the acceleration from her hand runs out.
e. Yes, because otherwise the ball would fall down immediately.
f. Yes, because the air currents carry the ball upwards.

Problem 9. You drop a 4 kg stone from rest down a 5 m well. How long will it take to reach the bottom?

a. Less than 0.36 s
b. 0.36 – 0.50
c. 0.50 – 0.64
d. 0.64 – 0.78
e. 0.78 – 0.92
f. 0.92 – 1.06
g. More than 1.06 s

Problem 10. George enters a straight freeway and travels at a constant speed of 60 mi/hr. Fred enters the freeway 20 minutes later traveling at a constant speed of 70 mi/hr in the same direction. When Fred passes George, how far has he gone on the freeway?

a. Less than 125 miles
b. 125- 145
c. 145 – 165
d. 165 – 185
e. 185 – 205
f. 205 – 225
g. More than 225 miles

Problem 11. The pilot of an airplane sees that his heading is due west (the direction the nose of the plane is pointing, i.e., the plane's direction relative to the air) and that his airspeed (speed of the plane relative to the air) is 150 mph. If there is a wind of 40 mph toward the north (speed of the air relative to the ground), what is the magnitude of the airplane's velocity relative to the ground?

a. $\sqrt{150^2 - 40^2}$ mph
b. $\sqrt{150^2 + 40^2}$
c. $150 - 40$
d. $150 + 40$ mph

Problem 12. Winston throws a ball at an upward angle across a flat field. The ball leaves his hand 2 meters above the ground, and it lands on the field some distance away. At what part of its path does the ball have its maximum speed?

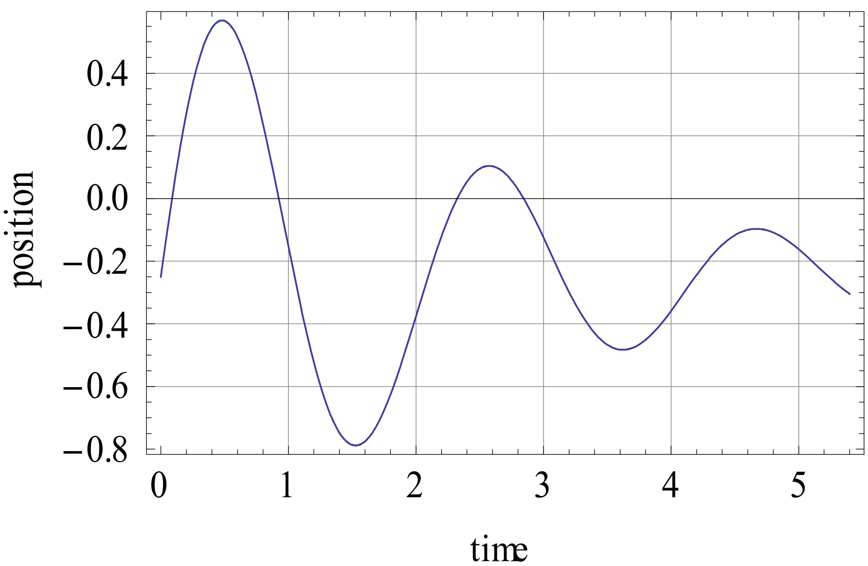
a. At the top of its path
b. Halfway to the top
c. Right after it leaves his hand **(typo: it said "my hand")**
d. Right before it hits the ground
e. There's not enough information to say

Problem 13. Sharon and Rob each throw a rock horizontally from a cliff overlooking the ocean. Sharon throws her rock fast. Rob throws his slower. Which rock will be going fastest (vector magnitude) just before it hits the water?

a. Sharon's
b. Rob's
c. Neither; the rocks will have the same speed

Problem 14. Jim walks back and forth for a bit; his position vs. time graph is shown. What was Jim's average velocity between 1.0 and 1.5 seconds?

a. Less than -0.95 m/s
b. Between -0.95 and -0.65
c. Between -0.65 and -0.35
d. Between -0.35 and -0.05
e. Between -0.05 and +0.25
f. Between +0.25 and +0.55
g. Between +0.55 and +0.85
h. More than 0.85 m/s

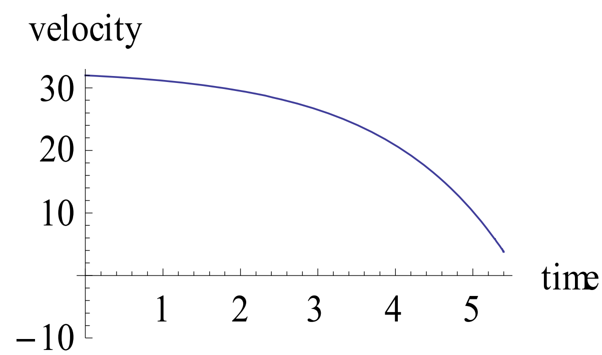


Problem 15. Same situation. What was Jim's instantaneous velocity at 3.6 seconds?

a. Less than -0.3 m/s
b. Between -0.3 and -0.1
c. Between -0.1 and +0.1
d. Between +0.1 and +0.3
e. More than +0.3 m/s

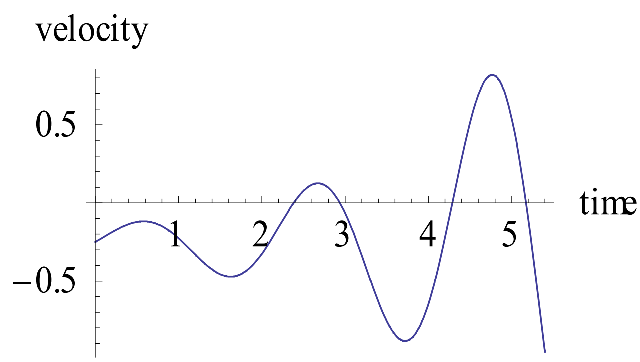
Problem 16. The figure shows a velocity vs time graph of a car moving along a road, and positive means "to the right". According to the graph, what is the car doing?

a. moving to the left and slowing down
b. moving to the left and speeding up
c. moving to the right and slowing down
d. moving to the right and speeding up
e. first moving right, then moving left
f. first moving left, then moving right



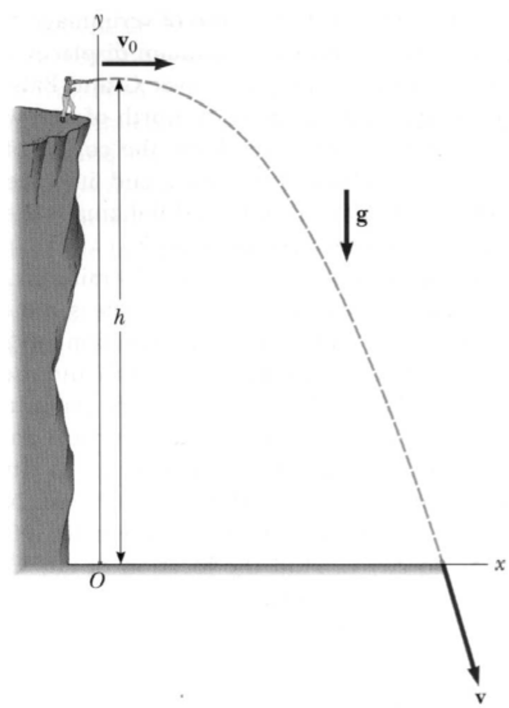
Problem 17. A block moves back and forth in a straight line, and has the velocity vs time graph given in the figure. Positive means "to the right". How many times did the block turn around during this period of time?

a. 0
b. 1
c. 2
d. 3
e. 4
f. 5



Problem 18. A student stands at the edge of a cliff and throws a stone horizontally over the edge with a speed of v_0 = 24 m/s. The cliff is a height h = 20 m above a horizontal beach, as shown in the figure. How far to the right of the cliff will the stone strike the beach? Hint: first find the time it will take.

a. Less than 30 m
b. 30 – 35
c. 35 – 40
d. 40 – 45
e. 45 – 50
f. 50 – 55
g. 55 – 60
h. More than 60 m



Problem 19. A hiker follows her compass due north for 4 miles. She then follows a direction 30° N of E (or 60° E of N) for 8 miles. How many miles is she from where she started?

a. $4-8\cos 30^\circ$

b. $4-8\sin 30^\circ$

c. $4+8\cos 30^\circ$

d. $4+8\sin 30^\circ$

e. $\sqrt{\left(4-8\cos 30^\circ\right)^2+\left(8\sin 30^\circ\right)^2}$

f. $\sqrt{\left(4-8\sin 30^\circ\right)^2+\left(8\cos 30^\circ\right)^2}$

g. $\sqrt{\left(4+8\cos 30^\circ\right)^2+\left(8\sin 30^\circ\right)^2}$

h. $\sqrt{\left(4+8\sin 30^\circ\right)^2+\left(8\cos 30^\circ\right)^2}$

Problem 20. A man holding a rifle at height $y = 0$ tries to hit the side of a large barn 100 m away. The rifle is shot at 2.9º above the horizontal. The initial velocity of the bullet is 200 m/s. What is the y-position in meters of the hole the bullet makes in the side of the barn? Use sin(2.9°) = 0.05, cos(2.9°) = 1.00. Hint: first find the time it will take.

a. Less than 2.0 m
b. 2.0 – 2.4
c. 2.4 – 2.8
d. 2.8 – 3.2
e. 3.2 – 3.6
f. 3.6 – 4.0
g. More than 4.0 m