Physics 100A – S 06 - Final Exam B 07/13/07

Name: Please show all your work

1. A car is moving with a velocity (4.5 m/s) $\hat{x}$ - (1.0 m/s) $\hat{y}$ and 2.5 seconds later its velocity is - (6.0 m/s) $\hat{x}$ + (3.0 m/s) $\hat{y}$. What is the magnitude of the average acceleration of the car? (5.0 points)

$$\vec{V}_i = 4.5\,\hat{x} - 1.0\,\hat{y} \qquad \Delta t = 0$$

$$\vec{V}_f = -6.0\,\hat{x} + 3.0\,\hat{y}$$

$$\vec{a} = \frac{\Delta \vec{V}}{\Delta t} = \frac{(\vec{V}_f - \vec{V}_i)}{\Delta t} = \frac{(-6.0-4.5)}{2.5}\hat{x} + \frac{(3.0+1.0)}{2.5}\hat{y}$$

$$= -\frac{10.5}{2.5}\hat{x} + \frac{4.0}{2.5}\hat{y} = -4.2\,\hat{x} + 1.6\,\hat{y}$$

$$a = \sqrt{a_x^2 + a_y^2} = \sqrt{4.2^2 + 1.6^2} = 6.7 \text{ m/s}$$

2. Astronauts on our moon must function with an acceleration due to gravity of 0.170 g. If an astronaut can throw a certain wrench 12.0 m vertically upward on earth, how high could he throw it on our moon if he gives it the same starting speed in both places? (5.0 points)

$$g_M = 0.170\, g = 1.67 \text{ m/s}^2$$

$$\Delta y_E = 12.0 \text{ m} \qquad V_f = 0 \qquad V_{iE} = V_{iM}$$

$$V_f^2 = V_i^2 - 2g\Delta y$$

$$V_{iE} = \sqrt{2g\Delta y_E} = V_{iM} = \sqrt{2g_M\Delta y_M}$$

$$\cancel{2}g\Delta y_E = \cancel{2}\Delta y_M$$

$$\Delta y_M = \frac{g}{g_M}\Delta y_E = \frac{9.81}{1.67}12.0$$

$$\Delta y_M = 70.6 \text{ m}$$

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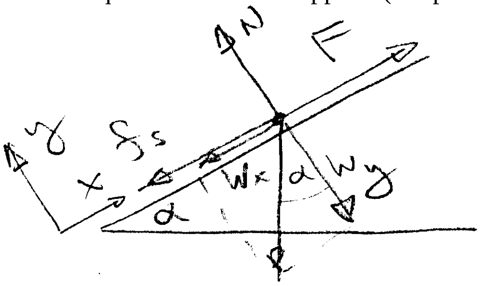
3. A 60.0-kg block is being pulled up a 25.0^0 slope by a force of 325 N which is parallel to the slope, but the block does not slide up the slope. What is the minimum value of the coefficient of static friction required for this to happen? (5.0 points)



$m = 60.0$ kg
$\alpha = 25.0°$
$F = 325$ N

$W_x = mg\sin\alpha$
$W_y = mg\cos\alpha$

$$\Sigma F_y = N - mg\cos\alpha = 0$$
$$N = mg\cos\alpha$$

$$\Sigma F_x = F - f_s - W_x = 0 \qquad f_s = \mu_s N$$

$$F - \mu_s mg\cos\alpha - mg\sin\alpha = 0$$

$$\mu_s = \frac{F - mg\sin\alpha}{mg\cos\alpha}$$

$$\mu_s = \frac{325 - 60\ 9.81\ \sin 25°}{60\ 9.81\ \cos 25°}$$

$$= \frac{76.5}{533} = 0.143$$

4. A 1200-kg car coasts on a horizontal road with a speed of 20 m/s. After crossing an unpaved, sandy stretch of road 30.0 m long its speed decreases to 12 m/s. Find the magnitude of the average net force on the car in the sandy section. (5.0 points)

$m = 1200$ kg
$V_i = 20$ m/s
$V_f = 12$ m/s
$d = 30.0$ m

$$W_{NC} = \Delta K = K_f - K_i$$
$$-F_{av} d = \frac{1}{2} m (V_f^2 - V_i^2)$$

$$F_{av} = \frac{m}{2d}(V_i^2 - V_f^2) = \frac{1200}{2\ 30.0}(20^2 - 12^2)$$

$$F_{av} = 5{,}120 \text{ N}$$

7. A mass is oscillating on a spring with a period of 4.60 s. At t = 0 s the mass has zero speed and is at x = 8.30 cm. What is its speed at t = 2.50 s? (5.0 points)

$T = 4.60\ s \qquad x = A\cos\omega t \qquad A = 8.30\,cm$

$t = 2.50\ s \qquad x = 8.30\cos\frac{2\pi}{T}t \qquad \omega = \frac{2\pi}{T}$

$V = -A\omega\sin\omega t = -A\omega\sin\frac{2\pi}{T}t$

$= -\frac{8.30\ 2\pi}{4.60}\sin\left(\frac{2\pi}{4.60}\,2.50\right)$

$= -11.3\,\frac{cm}{s}\,(-0.2698) = +3.06\,cm/s$

8. When a 0.213-kg mass is attached to a vertical spring, it causes the spring to stretch a distance d. If the mass is now displaced slightly from equilibrium, it is found to make 102 oscillations in 56.7 s. Find the stretch distance, d. (5.0 points)

$m = 0.213\ kg \qquad d = ?$

$T = \frac{56.7}{102}s = 0.556\ s \qquad T = 2\pi\sqrt{\frac{m}{k}}$

$k = \frac{4\pi^2}{T^2}m = \frac{4\pi^2}{0.556^2}\,0.213 = 27.2\,\frac{N}{m}$

$F = kx = mg$

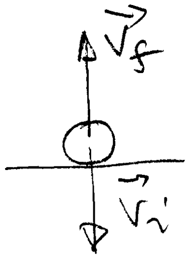
$x = \frac{mg}{k} = \frac{0.213\ 9.81}{27.2}$

$x = 0.077\,m = 7.7\,cm$

5. A 0.140-kg baseball is dropped from rest. It has a speed of 1.20 m/s just before it hits the ground. It rebounds with a speed of 1.00 m/s. The ball is in contact with the ground for 0.0140 s. What is the average force exerted by the ground on the ball during that time? (5.0 points)

$\vec{V}_i = -1.20\ \hat{y}$ $m = 0.140$ kg

$\vec{V}_f = 1.00\ \hat{y}$ $\Delta t = 0.0140$ s

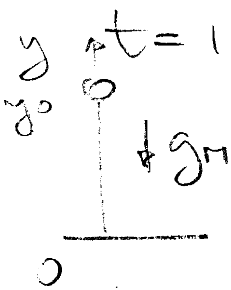


$$F_{av} = \frac{\Delta p}{\Delta t} = \frac{m(V_f - V_i)}{\Delta t}$$

$$= \frac{0.140\,(1.00 - (-1.20))}{0.0140}$$

$$= 22.0 \text{ N} \quad (\text{up})$$

6. An astronaut drops a marble on the surface of Mars and observes that it takes 1.02 s for the marble to fall 2.00 m. She also knows that the radius of Mars is 3.39 10^6 m. What is the mass of Mars? (5.0 points)



$t = 1.02$ s $\Delta y = 2.0$ m $R_M = 3.39\ 10^6$ m

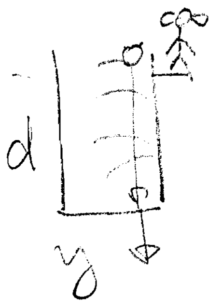
$$\Delta y = \frac{1}{2} g_M t^2 \qquad g_M = \frac{2\Delta y}{t^2} = \frac{2\ 2.00}{1.02^2}$$

$$G = 6.67\ 10^{-11} \frac{\text{N m}^2}{\text{kg}} \qquad g_M = 3.84 \text{ m/s}^2$$

$$g_M = G\frac{M_M}{R_M^2} \Rightarrow M_M = \frac{g_M R_M^2}{G}$$

$$M_M = \frac{3.84\,(3.39\ 10^6)^2}{6.67\ 10^{-11}} = 6.62\ 10^{23} \text{ kg}$$

9. A rock is thrown downward into a well that is 8.8 m deep. If the splash is heard 1.2 seconds later, what was the initial speed of the rock? The speed of sound in air is 343 m/s. (5.0 points)



$d = 8.8\,m \quad t_T = 1.2\,s \quad t_R = ?$

$t_S = \frac{d}{V_s} = \frac{8.8}{343} = 0.0256\,s$

$t_R = t_T - t_S = 1.2 - 0.0256\,s$

$t_R = 1.174\,s$

$\Delta y = d = 0 + V_0 t_R + \frac{1}{2} g t_R^2$

$V_0 = \frac{d - \frac{1}{2} g t_R^2}{t_R} = \frac{8.8 - \frac{1}{2}\,9.81\ 1.174^2}{1.174} = \underline{1.73}\,\frac{m}{s}$

10. Two train whistles, A and B, each have a frequency of 392 Hz. A is stationary and B is moving toward the right (away from A) at a speed of 35.0 m/s. A listener is between the two whistles and is moving toward the right with a speed of 15.0 m/s. (See Figure 1) What is the beat frequency detected by the listener? (5.0 points)

$V = V_S = 343\ m/s \qquad f = 392\ Hz$

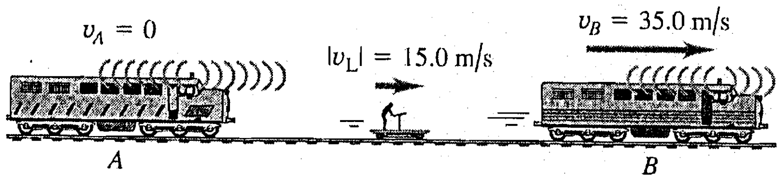


Figure 1

$u_0 = V_L = 15.0\ m/s$

$u_A = 0 = V_A$

$u_B = V_B = 35.0\ m/s$

$= \left(1 - \frac{u_0}{V}\right) f = \left(1 - \frac{15}{343}\right) 392$

$f'_A = 375\ Hz$

$f'_B = \left(\frac{1 + \frac{u_0}{V}}{1 + \frac{u_B}{V}}\right) f = \frac{\left(1 + \frac{15}{343}\right)}{\left(1 + \frac{35}{343}\right)} 392$

$f'_B = 371$

$\Delta f = |f'_B - f'_A| = |371 - 375| = 4\ Hz$