1. The radial acceleration of an object travelling in a circle of radius r at a constant speed v is

$$a = v^2 / r$$

Suppose the velocity of a particular orbiting object is 5.5±0.1 m/s at a radius of 2.00±0.08 m. What is the acceleration of the object with its uncertainty?

A. $15.13 \pm 0.08\ m/s^2$
B. $15.1 \pm 0.1\ m/s^2$
C. $15.1 \pm 0.2\ m/s^2$
D. $15.1 \pm 0.9\ m/s^2$ ✓
E. $15 \pm 1\ m/s^2$

$V = 5.5 \pm 0.1$ $\quad r = 2.00 \pm 0.08$

$V^2 = 30.25$

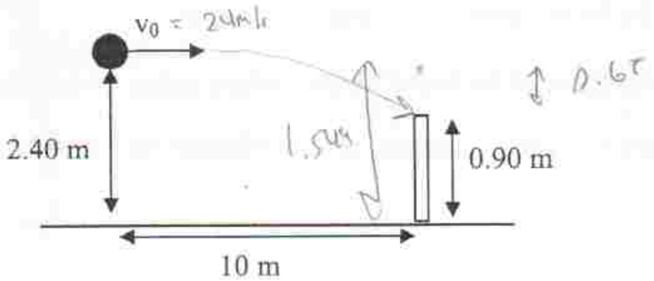
$\Delta V^2 = 2 V \Delta V$
$= 1.1$

$$a = \frac{V^2}{r} \pm \frac{V^2}{r}\left(\frac{\Delta V^2}{V^2} + \frac{\Delta r}{r}\right)$$

$= 15.125 \pm 15.125\,(0.03636 + 0.04)$ $\quad 0.07636$

$= 15 \pm 1.155$

2. During a tennis match, a player serves a ball. It leaves her racquet with a speed of 24 m/s horizontally at a height of 2.40 m above the ground. The net is 90 cm high and 10 m away. What is the result of the serve?



$V = \frac{d}{t}$ ✓

A. The ball clears the net by 0.85 m
B. The ball clears the net by 0.65 m
C. The ball hits the net 0.05 m below the top of the net.
D. The ball hits the net 0.85 m below the top of the net.
E The ball never reaches the net.

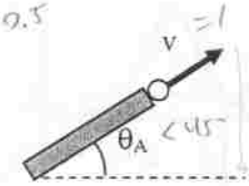
x-dir
$V_x = 24\ m/s$
$d_x = 10\ m$
$t_x = 0.4167\ s$

y-dir
$V_{yi} = 0$
$V_{yf} = ?$
$a = -9.8$
$d_y = 2.4$
$t_y = 0.4167\ s$

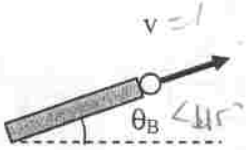
$Y_f = V_{yi}t + \frac{1}{2}at^2 + Y_i$
$Y_f - Y_i = -\frac{1}{2}gt^2$
$Y_f - 2.4 = -\frac{1}{2}gt^2$
$Y_f = 1.549$

3. Softballs are fired from two different pitching machines with the *same initial speeds*, but at two *different* initial angles, as shown. θ_A and θ_B are both less than 45°. Which softball spends more time in the air?

$V_{yi} = \sin 30° = 0.5$
$a = -9.8$
$\Delta d = 0$
$t_y = ?$



A



B

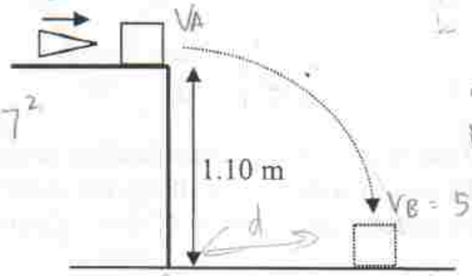
$v_{yi} = \sin 15° = 0.26$
$a = 9.8$
$\Delta d = 0$
$t_y = ?$

$0 = V_{yi} t - \frac{1}{2} g t^2$
$0 = 0.5t - 4.9t^2$
$t = 0.102$

$0 = 0.26t - 4.9t^2$
$t = 0.053$

A. Softball A spends more time in the air.
B. Softball B spends more time in the air.
C. Both softballs spend the same amount of time in the air.
✓ D. More information is required.

4. A 7.50 g bullet is fired into a 2.06 kg block that is initially at rest at the edge of a frictionless table of height 1.1 m, as depicted in the diagram. The bullet remains in the block. Just before the block hits the ground, it has a speed of 5.47 m/s. Calculate the initial speed of the bullet.



$V_x^2 + V_y^2 = 5.47^2$

bullet
$m_1 = 0.0075$ kg
$V_{1i} = ?$
$V_{1f} = V_{2f}$

block
$m_2 = 2.06$ kg
$V_{2i} = 0$

$m_1 V_{1i} + m_2 V_{2i} = (m_1 + m_2) V_x$

$V_x = \frac{m_1 V_{1i}}{m_1 + m_2} = \frac{0.0075 V_{1i}}{2.0675} = 3.628 \times 10^{-3} V_{1i}$

A. 224 m/s
B. 305 m/s
✓ C. 324 m/s
D. 586 m/s − $V_x = 2.126$
E. 797 m/s − $V_x = 2.89$

$V = \frac{d}{t}$

$1.1 = -\frac{1}{2} g t^2$
$t = 0.474$ s

x-dir
V_{xi}
$d_x = d_x$
$t = 0.474$

y-dir
$V_{yi} = 0$
$V_{yf} = \sqrt{5.47^2 - V_A^2} = 5.04$
$d = 1.10$ m
$a = -9.8$
$t = 0.474$

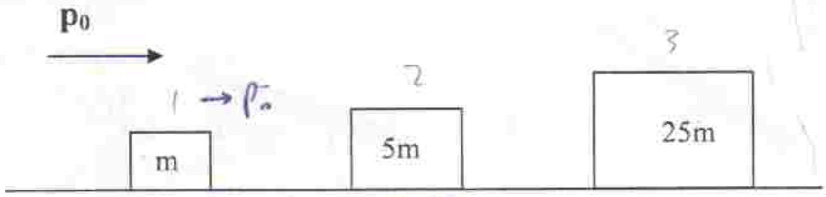
$V_{yf} = 4.64$

$d = V_f t - \frac{1}{2} a t^2$

$V_2^2 = V_1 + 2ad$
$V_{yf} = 4.64$

$V_x^2 =$

5. Three blocks sit on a horizontal frictionless surface. The blocks have masses m, 5m, and 25m, as shown in the diagram. The block of mass m is given an initial momentum p_0 to the right and a series of collisions ensues. All the collisions between the blocks are elastic.



$p_0 = m V_{1i}$ $\leftarrow -\bar{P}_0$ p $\overrightarrow{P_5}$

$\bar{P_5} + (-\bar{P}_0) = \bar{P}_0 \quad \therefore P_5 > P_0$ $\quad -\bar{P}_5 + P_{25} = P_{2f}$

$P_{25} > P_5$

When all of the collisions are over, the momentum of the largest block is?

A. greater than p_0.
B. equal to p_0.
C. less than p_0.

1st collision

$V_{2f} = \frac{(m_2 - m_1)}{(m_1 + m_2)} V_{2i} + \frac{2m_1}{(m_1+m_2)} V_{1i}$

$= \frac{4m}{6m} V_{2i} + \frac{2m}{6m} V_{1i}$

$V_{2f} = \frac{1}{3} V_{1i}$

$= V_{2i}$ for collision #2

2nd collision

$V_{3f} = \frac{(m_3 - m_2)}{(m_2 + m_3)} V_{3i} + \frac{2 m_2}{(m_2 + m_3)} V_{2i}$

$= \frac{10m}{30m} V_{2i}$

$= \frac{1}{3} V_{2i}$

$= \frac{1}{3}\left(\frac{1}{3} V_{1i}\right)$

$P_3 = 25m\left(\frac{1}{9} V_{1i}\right)$
$= 2.77 V_{1i}$

6. A 540 g bird flying along at 7.80 m/s sees a 14.2 g insect heading straight toward it with a speed of 26.3 m/s. The bird opens its mouth wide and swallows the insect. If the collision lasts 0.420 s, what is the magnitude of the average acceleration of the bird during the collision?

A. 1.04 m/s^2
B. 2.13 m/s^2
C. 7.80 m/s^2
D. 10.56 m/s^2
E. 26.30 m/s^2

bird
$m_1 = 0.54$ kg
$V_{1i} = 7.8$ m/s

insect
$m_2 = 0.0142$
$V_{2i} = -26.3$

$m_1 V_{1i} + m_2 V_{2i} = (m_1 + m_2)(V)$
$4.446 - 0.373 = 0.5542\ V$
$V = 6.93$ m/s

bird
$P_i = 4.212$
$P_f = 4.073$
$\Delta P = 0.13863$

$\Delta p = F \Delta t$
$\Delta p = m a \Delta t$
$0.13863 = m a \Delta t$

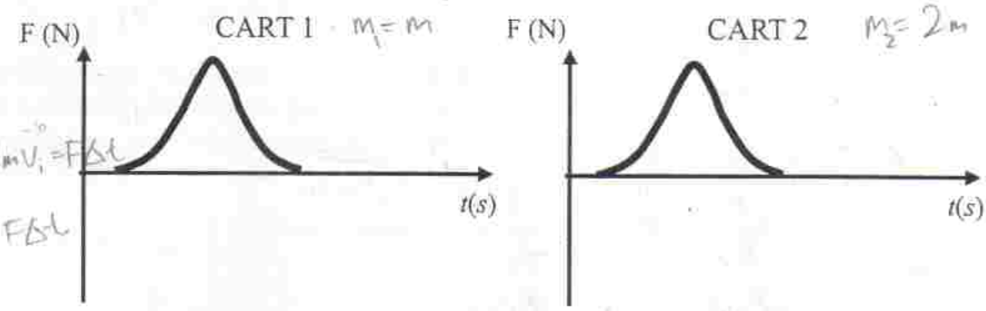
$a = \frac{V_2 - V_i}{\Delta t} = 2.07$

7. Cart 1, of mass m is travelling to the right with speed v. It collides with Cart 2, of mass 2m, which was originally travelling towards the left with the same speed. Which of the following force vs. time graphs for the two carts best represents the situation?

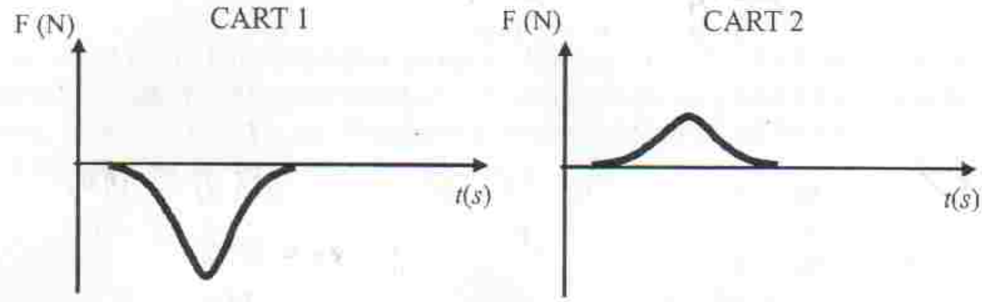
$V_i = 10$
$V_f = 0$
Cart 1
$\Delta P = F\Delta t$
$mV_f - mV_i = F\Delta t$
$-10m = F\Delta t$

$V_i = -10$
$V_f = 0$
Cart 2
$2mV_f - 2mV_i = F\Delta t$
$20m = F\Delta t$

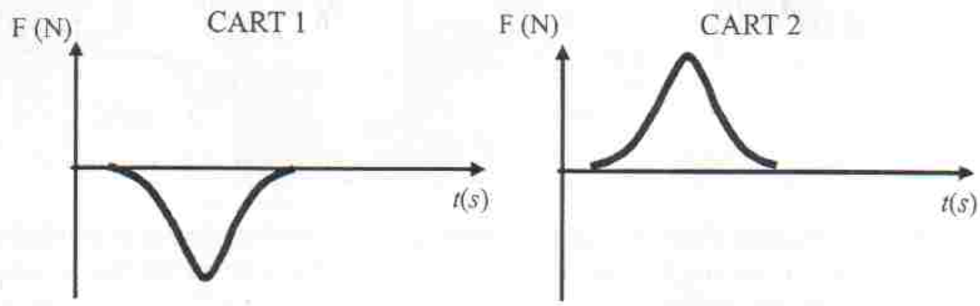
A.



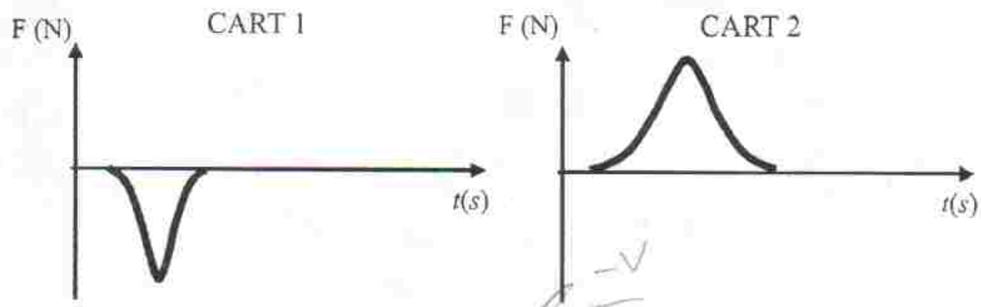
B.

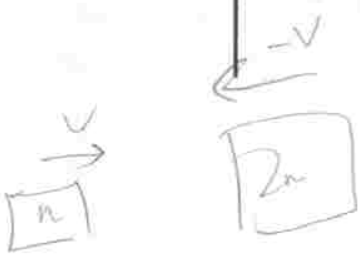


C.



D.





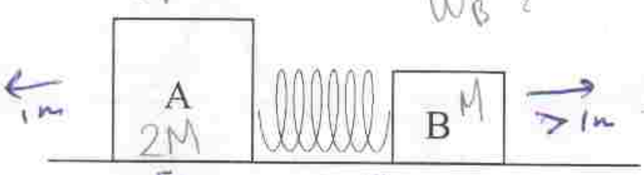
E. None of the above

$0 = 2A + B$ if $B = 2$
$B = -2A$ $A = -1$

8. Two blocks, A and B, are held on a level, frictionless surface with a compressed spring between them. Block A has twice the mass of block B.

$W_A = \left(\frac{1}{2} V_B\right)^2 = \frac{1}{4} V_B^2 = \frac{1}{4}(2)^2 = 1$

$W_B = (2V_A)^2 = 4V_A^2 = 4(1)^1 = 4$



$W = F\Delta x$

$F_A = F_B$

$\Delta x_A < \Delta x_B$

$W_A < W_B$

When released, the blocks fly apart and the spring is left behind. Let W_A be the magnitude of the work done by the spring on block A, and W_B the magnitude of the work done by the spring on block B. Which of the following statements is correct?

A. $W_A < W_B$
B. $W_A = W_B$
C. $W_A > W_B$.

$W = \Delta K = \frac{1}{2} m v_f^2$

$0 = 2MV_A + MV_B$

$2MV_A = MV_B$

$V_A = \frac{MV_B}{2M} = \frac{1}{2} V_B$

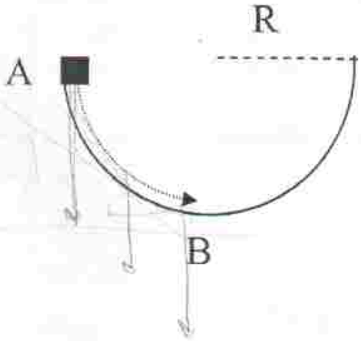
$V_B = 2V_A$

$W_A = \frac{1}{2}(2M) V_f^2$

$W_A = V^2$

$W_B = \frac{1}{2} V^2$

9. A small block slides down the side of a semi-circular bowl as shown in the diagram. The radius of the bowl is R. How much work is done by the force of gravity as the block slides down the bowl between the points A and B.



$2\pi r$ Circum $= 2\pi R$

$\frac{1}{4}$ of that $= \frac{\pi R}{2}$

$W_g = mg \cdot d$

A. $(\pi R)\ mg$
B. $(\pi R/2)\ mg$
C. $R\ mg$
D. $(R/\sqrt{2})\ mg$
E. $(\sqrt{2}\ R)\ mg$

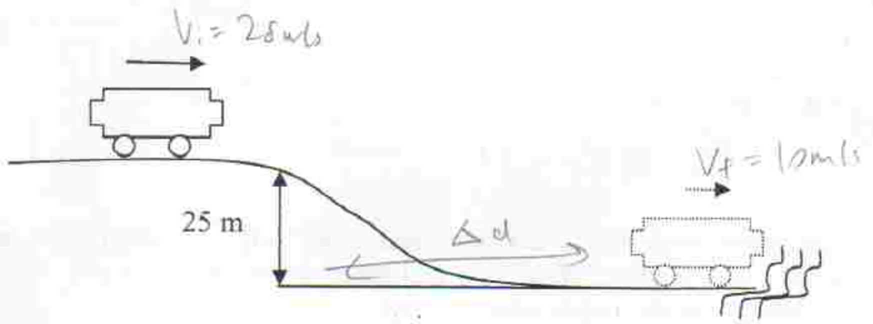
10. A ping-pong ball and a bowling ball are rolling towards you. The balls have the same momentum, and you exert the same force to stop them. How do the time intervals to stop them compare

A. It takes longer to stop the bowling ball.
B. It takes longer to stop the ping-pong ball.
C. It takes the same time to stop either ball.

$\Delta p = F\Delta t$ $\qquad\qquad$ $\Delta p = F\Delta t$

$\Delta t = \frac{\Delta p}{F}$ $\qquad\qquad$ $\Delta t = \frac{\Delta p}{F}$

11. The driver of a 1500 kg car, travelling at 28 m/s, comes over the crest of a hill to find that the road has been washed out below him. He slams on his brakes and skids down the hill. Unfortunately, he is still moving at 10 m/s when he reaches the gully.



How much energy is lost to the frictional force between the car and the road while the car is slowing?

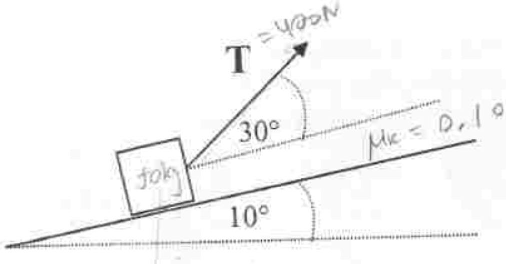
A. 146 kJ
B. 368 kJ
C. 513 kJ
D. 881 kJ
E 956 kJ

$mgy + \frac{1}{2}mv_i^2 = \frac{1}{2}mv_f^2 + F_f \cdot \Delta d$

$367500 + 588000 = 7500 + F_f \cdot \Delta d$

$881\text{ kJ} = E_{th}$

12. A 50 kg block is being pulled up a 10° incline, as shown in the diagram. The pulling force makes an angle of 30° with the incline. The tension in the rope is 400 N and the coefficient of kinetic friction with the snowy surface is 0.10.



$\Delta x = 1.5m$

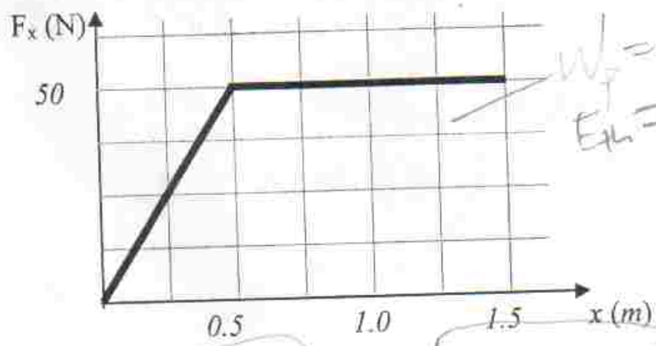
How much work is done by the tension in the rope in pulling the block 1.5 m up along the incline?

$W = T\cos 30° \cdot 1.5$

$= 520 J$

A. 42 J
B. 245 J
C. 350 J
D. 460 J
E. 520 J

13. The figure shows an approximate plot of the magnitude of the force of friction versus position for a 40-kg girl sliding on a mud puddle. The girl's initial speed at x = 0.0 m is 4 m/s. What is her speed when she reaches the end of the puddle at x = 1.5 m?



$W_f = 12.5 + 50$

$E_{th} = 62.5 J$

$= W$

$- E_{th}$

A. 0 m/s.
B. 1.14 m/s.
C. 2.47 m/s.
D. 3.57 m/s.
E. 5.66 m/s.

$m = 40kg$

$V_i = 4m/s$

$V_f = ?$

$0 = \Delta K + E_{th}$

$-625 = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$-62.5 = \frac{1}{2}mv_f^2 - 320$

$V_f = 3.58$

$0 = \Delta K + W_f$

$\frac{1}{2}mv_i^2 + E_{th} = \frac{1}{2}mv_f^2 + E_{th}$

320

$\boxed{I = 100\left(\frac{1}{3}t^3\right)\Big|_{t_1}^{t_2}}$ → $\Delta p = p_f - p_i$

F must be result $= mv_f - mv_i$

$\frac{x^{n+1}}{n+1}$

14. The resistive force on a car as it drives through a water filled trench may be modeled by the following formula:

$F = m\left(\frac{V_2 - V_1}{t}\right)$

$$F(t) = (100.0\ \mathrm{N/s^{-2}})\ t^2$$

$\int_{t_1}^{t_2} 100\,t^2\,dt$ / $100\int_{t_1}^{t_2} \frac{t^3}{3}$

If the 1100-kg car originally has a speed of 18.0 m/s, and it spends 4.50 s travelling from one side of the trench to the other, what is the car's speed on the other side of the trench?

$F = 3038$

$m = 1100$
$V_i = 18$ $\quad V_f = ?$
$\Delta t = 4.50$

$F = \frac{d(mv)}{dt}$

$a = \frac{dV}{dt}$

A. 7.61 m/s.
B. 12.62 m/s.
C. 15.23 m/s.
D. 18.56 m/s.
E. 26.9 m/s.

$mv_f - mv_i = F\Delta t$

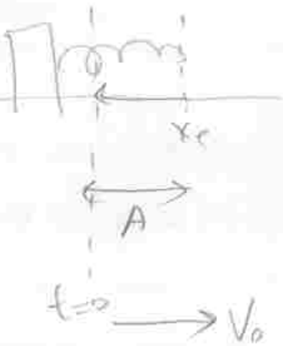
$= m\frac{dv}{dt} + \frac{dm}{dt}v$

$= \frac{m(v_2 - v_i)}{4.50} +$

$mv_f - mv_i = m\int_{t_1}^{t_2} a\,dt$

$V_f - 18 = \int_{t_1}^{t_2}$

15. A block is attached to the end of an ideal Hooke's law spring on a horizontal frictionless surface. An external force compresses the spring a distance A. At t=0, the block is released. At what time, as a fraction of the period of the oscillation (T), does the block first pass through its equilibrium position?



$x(t) = A\cos(\omega t + \varphi)$

$-A = A\cos(\omega t + \varphi)$

$-1 = \cos(\omega t + \varphi)$

$-1 = \cos\varphi$

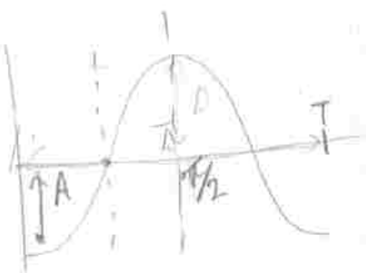
$\varphi = \pi$

A. T/8
B. T/4
C. T/√2
D. T/2
E. T

$\omega = \frac{2\pi}{T}$

$T = \frac{2\pi}{\omega}$

$0 = A\cos\left(\frac{2\pi}{T}t + \pi\right)$



The End