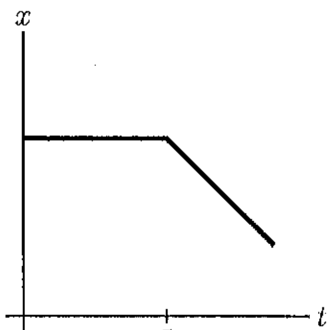
$V_0 = 25\,m/s,\ V = 0,\ a = -1.25\,m/s^2,\ X = ?\ \ x_0 = 0$

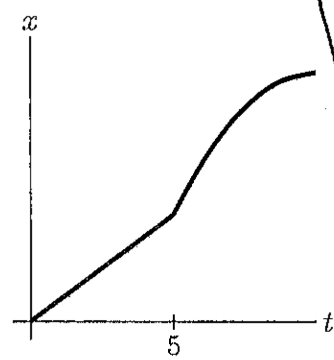
$\Rightarrow V^2 = V_0^2 + 2a(X - X_0) \Rightarrow X = \frac{(\cancel{V^2}^{\,0} - V_0^2)}{2(a)} = \frac{-(25\,m/s)^2}{2(-1.25\,m/s^2)} = +250\,m$

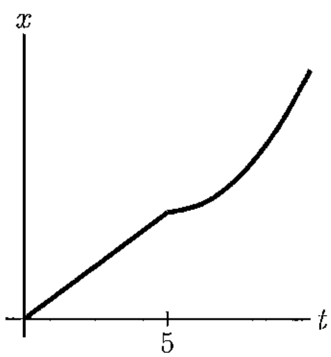
1. A car is traveling at $25.0\,m/s$ when the driver hits the brakes causing a constant deceleration of $1.25\,m/s^2$. How far does the car go while stopping?

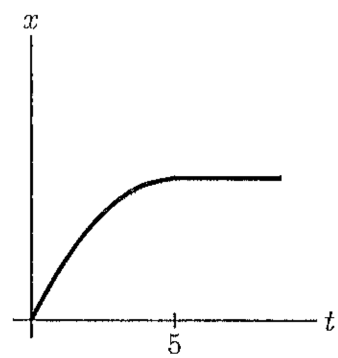
| | | | |
|---|---|---|---|
| (a) $750\,m$ | (b) $500\,m$ | $\boxed{\text{(c) } 250\,m}$ | (d) $20\,m$ |

2. Your physics instructor is driving his 1973, orange-colored Gremlin on Lomas Boulevard. For the first $5\,s$ of his trip, he maintains a constant velocity, but then he notices that there is an upcoming red stoplight so he hits the brakes and has a constant deceleration. Which of the following plots, correctly corresponds to his car's position versus time graph?

(a)



(b)



(c)


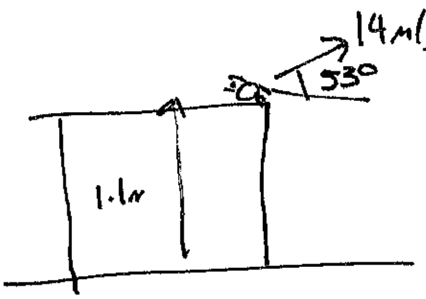

(d)



Constant velocity
$\Rightarrow a = 0$
$\therefore$ straight line

Constant deceleration
$\Rightarrow$ PARABOLA
with decreasing slope, i.e.

3. A grasshopper launches itself from the top of a table that is 1.1 $m$ high with speed 14 $m/s$ and at a 53° angle. How far from the table does the grasshopper land (what horizontal distance) if we ignore air resistance?

| (a) 206 $m$ | (b) 33.3 $m$ | $\boxed{\text{(c) } 20.0\,m}$ | (d) 6.63 $m$ |
|---|---|---|---|




$\vec{V_0} = 14\,m/s$ at $53°$

$\Rightarrow V_{0,x} = 14\,m/s \cos 53° = 8.425\,m/s$

$V_{0,y} = 14\,m/s \sin 53° = 11.18\,m/s$

$X = ?,\quad X_0 = 0,\quad y_0 = 1.1\,m,\ y = 0$

TO FIND $t$ USE $y = y_0 + V_{0,y}t - \frac{1}{2}gt^2 \Rightarrow 0 = 1.1\,m + 11.18\,m/s\,t - 4.9t^2$

$\Rightarrow (4.9\,m/s^2)t^2 - 11.18\,m/s\,t - 1.1\,m = 0 \Rightarrow t = \dfrac{11.18\,m/s \pm \sqrt{(11.18\,m/s)^2 - 4(4.9\,m/s^2)(-1.1\,m)}}{2(4.9\,m/s^2)}$

$\Rightarrow t = \dfrac{11.18\,m/s \pm \sqrt{146.5524\,m^2/s^2}}{9.8\,m/s^2} = 2.376\,s$ OR $\cancel{-.094}\,s$

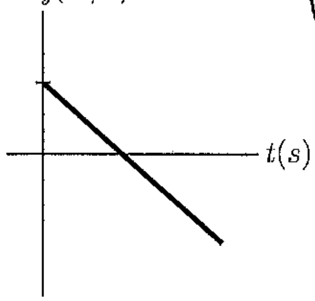
$X = \cancel{X_0}^{\,0} + V_{0,x}t = (8.425\,m/s)(2.376\,s) = 20.0\,m$

4. For the grasshopper of the previous problem, which of the following is the correct $v_y$ vs. $t$ graph for its motion?

$V_y$ vs. $t$ is straight line

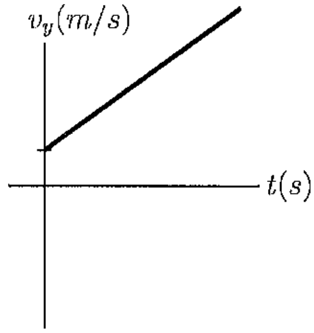
at top $V_y = 0$

(a)

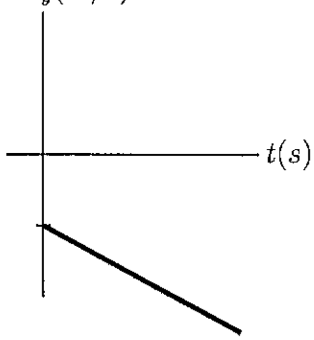



Only graph that passes through zero $V_y$

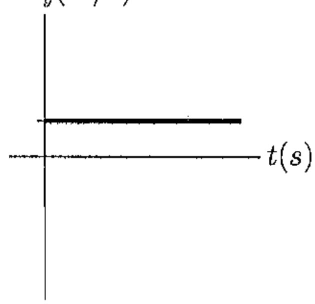
(b)




(c)

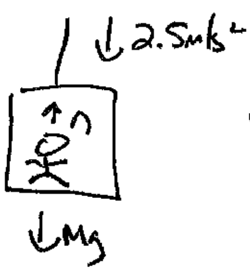



(d)




5. An 80-$kg$ man is riding in an elevator that is accelerating downwards at $2.5\,m/s^2$. What is the magnitude of his apparent weight?

| | | | |
|---|---|---|---|
| (a) 984 $N$ | (b) 784 $N$ | (c) 584 $N$ | (d) 200 $N$ |

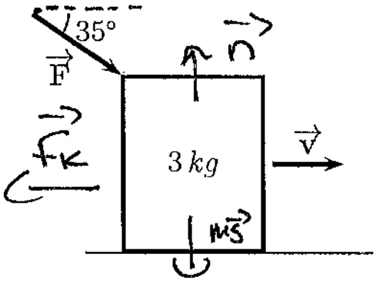



$n = ?$ $\quad \sum F_y = Ma_y \Rightarrow n - Mg = Ma_y. \quad a_y = -2.5\,m/s^2$

$\therefore\ n = Mg + Ma_y = M(g + a_y) = 80\,kg\,(9.8\,m/s^2 - 2.5\,m/s^2)$

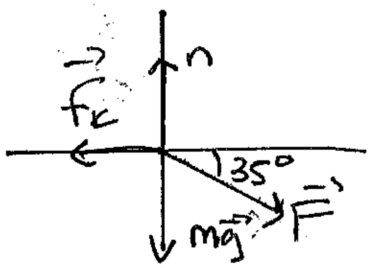
$\Rightarrow n = 80\,kg\,(7.3\,m/s^2) = 584\,N$

6. A 3.0 $kg$ crate is being pushed across a horizontal floor by applying a force $F = 27\,N$, 35° below the horizontal. If the coefficient of kinetic friction between the mass and the floor is $\mu_k = 0.45$, what is the acceleration of the crate?




| | |
|---|---|
| (a) $11.7\,m/s^2$ | (b) $7.37\,m/s^2$ |
| (c) $2.96\,m/s^2$ | (d) $0.639\,m/s^2$ |

FORCES: $\vec{n}$ UP, $M\vec{g}$ DOWN, $\vec{f_K}$ to left ($f_K = \mu_K n$)
AND $\vec{F}$




$\sum F_x = Ma_x$, $\sum F_y = Ma_y$.

MOTION TO RIGHT $\Rightarrow a_y = 0$

$\therefore \sum F_y = Ma_y \Rightarrow n - Mg - F\sin 35° = 0$

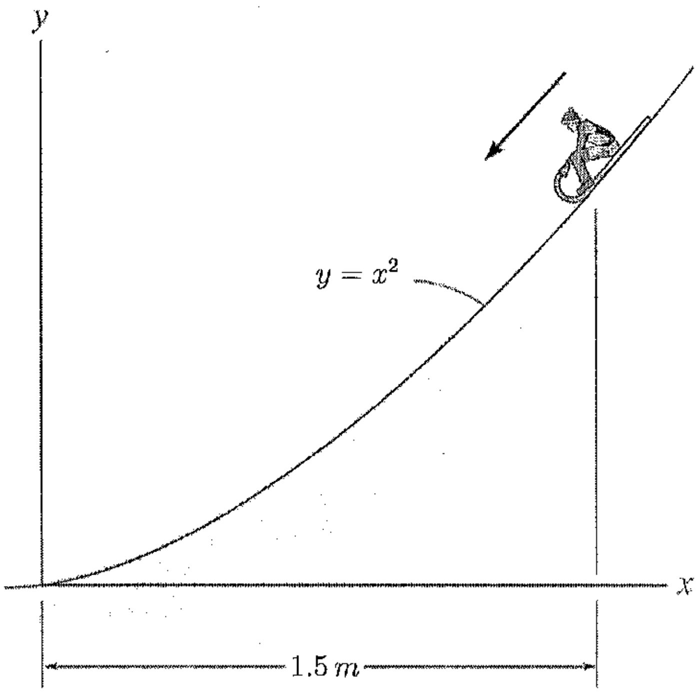
$\Rightarrow n = Mg + F\sin 35° = (3kg)(9.8\,m/s^2) + 27N\sin 35° = 44.89N$

$f_K = \mu_K n = .45(44.89N) = 20.2N$

$\sum F_x = Ma_x$. $a_x = a = ?$ $\Rightarrow F\cos 35° - f_K = Ma$

$\Rightarrow 27N\cos 35° - 20.2N = 3kg(a) \Rightarrow a = \frac{1.917N}{3kg} = .639\,m/s^2$

7. A boy rides a sled down an icy (and therefore frictionless) hill whose height above the ground is given by the equation $y = x^2$, where $y$ is in meters when $x$ is in meters. If he starts from rest at $x = 1.5\,m$, how fast will he be going at the bottom?




| | |
|---|---|
| (a) $5.42\,m/s$ | $\boxed{\text{(b) } 6.64\,m/s}$ |
| (c) $11.3\,m/s$ | (d) Not enough information to determine |

NO FRICTION $\Rightarrow$

$$\frac{1}{2}MV_1^2 + Mgy_1 = \frac{1}{2}MV_2^2 + Mgy_2$$

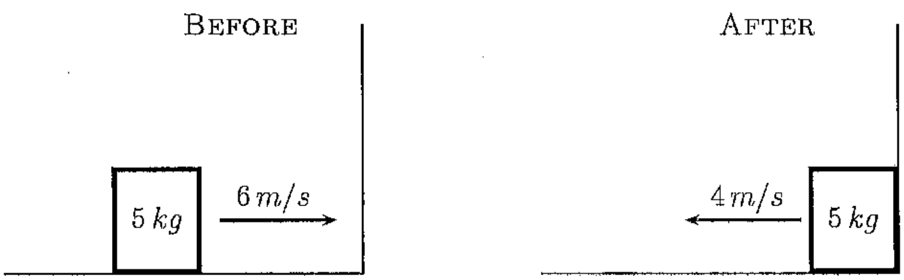
$$V_1 = 0,\ y_1 = (1.5)^2 = 2.25\,m$$

$$V_2 = ?,\ y_2 = 0$$

$$\therefore\ \cancel{M}gy_1 = \frac{1}{2}\cancel{M}V_2^2 \Rightarrow V_2 = \sqrt{2gy_1} = \sqrt{2(9.8\,m/s^2)(2.25\,m)}$$

$$\Rightarrow V_2 = 6.64\,m/s$$

8. A 5.0-$kg$ mass is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall. If the mass bounces back with a speed of $4.0\,m/s$ and the bounce time is $0.20\,s$, what is the magnitude and direction of the average force on the mass?



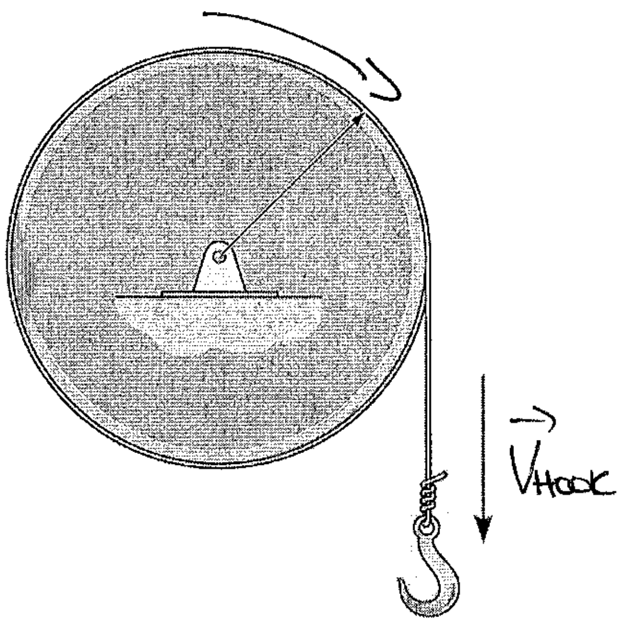

| | |
|---|---|
| (a) 250 $N$ to the left | (b) 250 $N$ to the right |
| (c) 50 $N$ to the left | (d) 50 $N$ to the right |

$$\vec{F}_{AV} = \frac{\Delta\vec{P}}{\Delta t} \Rightarrow F_{AV,x} = \frac{\Delta P_x}{\Delta t} = \frac{MV_{2,x} - MV_{1,x}}{\Delta t} = \frac{M(V_{2,x} - V_{1,x})}{\Delta t}$$

$$V_{2,x} = -4\,m/s,\ V_{1,x} = 6\,m/s \Rightarrow F_{AV,x} = \frac{5\,kg(-4\,m/s - 6\,m/s)}{.2\,s}$$

$$F_{AV,x} = \frac{5\,kg(-10\,m/s)}{.2} = -250\,N = 250\,N \text{ to left}$$

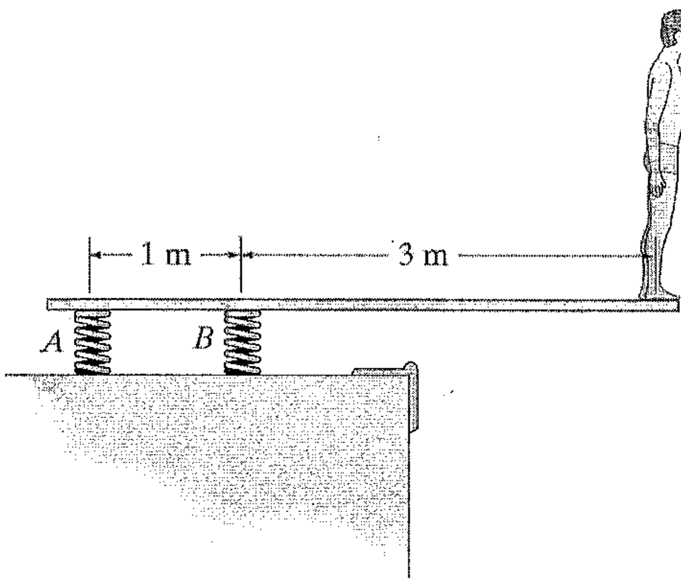
9. A very heavy hook is attached to a massless rope which has been wound around a drum that can rotate about its center. If the hook is released from rest, what direction is the drum's angular velocity?




| |
|---|
| (a) $\otimes$ |
| (b) $\odot$ |
| (c) *Up* |
| (d) *Down* |

As Hook Falls, Rope turns Drum Clockwise. RHR $\Rightarrow$ $\vec{\omega} = \otimes$ = into page

10. A 45 $kg$ man stands on the edge of a diving board as shown. Two springs, one at $A$ and the other at $B$, both exert vertical forces that keep the diving board (and man) horizontal and *prevent rotation.* How much force is the spring at $B$ exerting? Assume the axis of rotation of the diving board is at $A$.



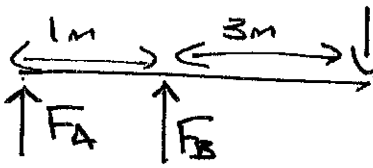

(a) 147 $N$

(b) 180 $N$

(c) 441 $N$

$\boxed{\text{(d) } 1764\ N}$

So "REAL" FBD OF DIVING BOARD




$Mg = (45kg)(9.8m/s^2) = 441N$

NO ROTATION $\Rightarrow \sum_i \tau = 0$. $F_A$ at $A \Rightarrow$ NO TORQUE

$F_B$ AND $Mg$ BOTH VERTICAL $\Rightarrow \tau_B = X_B F_B$, $\tau_g = X_g Mg$

$X_B = 1m$, $X_g = 1m + 3m = 4m$. AROUND A, $F_B$ tries to CAUSE Counter-clockwise

WHILE $Mg$ tries to CAUSE clockwise $\Rightarrow \sum_i \tau = \tau_B - \tau_g = 0 \Rightarrow \tau_B = \tau_g$

$\Rightarrow (1m)F_B = (4m)(441N) \Rightarrow F_B = 4(441N) = 1764N \leftarrow$ NOTE: THIS tells us that spring at A MUST PULL DOWN.

11. On some alien planet, you find that a 0.34-$m$ long simple pendulum has a period of 0.56 $s$, what is the acceleration due to gravity on that planet?

| (a) $0.106\,m/s^2$ | (b) $1.08\,m/s^2$ | (c) $9.8\,m/s^2$ | (d) $42.8\,m/s^2$ |
|---|---|---|---|

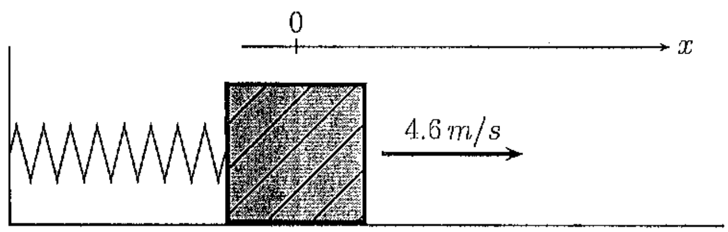
Simple Pendulum $\Rightarrow \omega = \sqrt{\frac{g}{L}} \Rightarrow \frac{2\pi}{T} = \sqrt{\frac{g}{L}} \Rightarrow T = \frac{2\pi}{\sqrt{g/L}}$

$\Rightarrow T = 2\pi\sqrt{\frac{L}{g}}$. $T^2 = \frac{4\pi^2 L}{g} \Rightarrow g = \frac{4\pi^2 L}{T^2}$

$g = \frac{4\pi^2(.34m)}{(.56s)^2} = 42.8\,m/s^2$

Let's hope you have a spacesuit on!

12. A $2\,kg$ mass is attached to a $50\,N/m$ spring as shown below. At time $t = 0$, the mass is started from its equilibrium position with a velocity of $4.6\,m/s$ to the right. There is no friction between the mass and the floor. What is the phase angle, $\phi$, in the equation $x = A\cos(\omega t + \phi)$ for this motion?




| | | | |
|---|---|---|---|
| (a) $-\frac{\pi}{2}$ | (b) $-\frac{2\pi}{5}$ | (c) 0 | (d) $\frac{2\pi}{5}$ |

$X_0 = 0, \quad V_0 = +4.6\,m/s$

$X = A\cos(\omega t + \phi) \Rightarrow X(t=0) = A\cos\phi \Rightarrow 0 = A\cos\phi$

$\Rightarrow \cos\phi = 0 \Rightarrow \phi = \pm\pi/2$ rad

$V = -\omega A\sin(\omega t + \phi) \Rightarrow V_0 = V(t=0) = -\omega A\sin\phi$

$V_0$ is positive $\Rightarrow \sin\phi < 0 \Rightarrow \boxed{\phi = -\pi/2}$

BY THE WAY $4.6\,m/s = -\omega A\sin(-\pi/2) = \omega A \Rightarrow A = \frac{4.6\,m/s}{\omega}$

$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{50}{2}} = \sqrt{25} = 5\,rad/s \Rightarrow A = \frac{4.6\,m/s}{5\,rad/s} = .92\,m$

13. Your starship, *The Aimless Wanderer*, is in circular orbit around a $4.0 \times 10^5$-$m$ radius, alien planet (which by law you have to call Mongo) with a period of 30.0 minutes. If *The Aimless Wanderer*'s distance *from the center of Mongo* is $4.5 \times 10^5\, m$, what is the acceleration due to gravity on the surface of planet Mongo?

Circular orbit $\Rightarrow T = \dfrac{2\pi r^{3/2}}{\sqrt{GM_M}}$

$r = 4.5\times10^5 m$ ← radius of orbit

$M_M$ = Mongo's mass

$T = 30 min \times \frac{60 s}{min} = 1800 s$

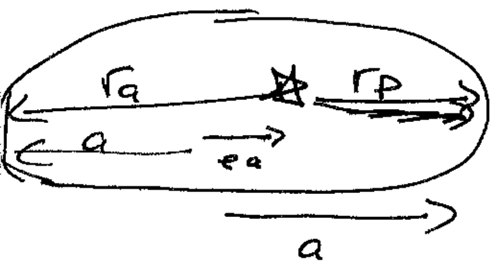
$g = \dfrac{GM_M}{R_M^2}$ $R_M$ = Mongo's radius $= 4\times10^5 m$ : Need Mongo's mass to find $g$, use period to find it.

$$T = \frac{2\pi r^{3/2}}{\sqrt{GM_M}} \Rightarrow T^2 = \frac{4\pi^2 r^3}{GM_M} \Rightarrow M_M = \frac{4\pi^2 r^3}{GT^2} = \frac{4\pi^2 (4.5\times10^5 m)^3}{(6.67\times10^{-11}\frac{N\cdot m^2}{kg^2})(1800 s)^2}$$

$$\Rightarrow M_M = 1.66\times10^{22} kg$$

$$\therefore g = \frac{GM_M}{R_M^2} = \frac{(6.67\times10^{-11}\frac{N\cdot m^2}{kg^2})(1.66\times10^{22} kg)}{(4\times10^5 m)^2} = 6.94 m/s^2$$

14. One of the brightest and most observed comets in the past 20 years was the Hale-Bopp comet. (Named in part for Alan Hale who first observed it from his driveway in New Mexico.) Comet Hale-Bopp is on a highly elliptical orbit with eccentricity 0.995. If comet Hale-Bopp starts at aphelion $5.55 \times 10^{13}\,m$ from the sun (mass $1.99 \times 10^{30}\,kg$) with a speed of $99.1\,m/s$, at what distance will it be and how fast will it be going when it reaches perihelion?




$ea + r_p = a \Rightarrow r_p = a - ea = a(1-e)$

TO FIND $a$: $a + ea = r_a \Rightarrow a(1+e) = r_a$

$$\Rightarrow a = \frac{r_a}{1+e} = \frac{5.55\times10^{13}\,m}{1.995} = 2.782\times10^{13}\,m$$

$$\therefore \boxed{r_p = 2.782\times10^{13}\,m\,(1-.995) = 2.782\times10^{13}(.005) = 1.39\times10^{11}\,m}$$

AT APHELION, $L = MV_a r_a$, AT PERIHELION $L = MV_p r_p$

CONSERVATION OF ANGULAR MOMENTUM $\Rightarrow MV_a r_a = MV_p r_p$

$$\Rightarrow V_p = V_a\left(\frac{r_a}{r_p}\right) = (99.1\,m/s)\left(\frac{\overset{5.55}{\cancel{2.782}}\times10^{13}}{1.39\times10^{11}}\right) = (99.1\,m/s)(399.28)$$

$$\Rightarrow \boxed{V_p = 39568.7\,m/s = 39600\,m/s}$$