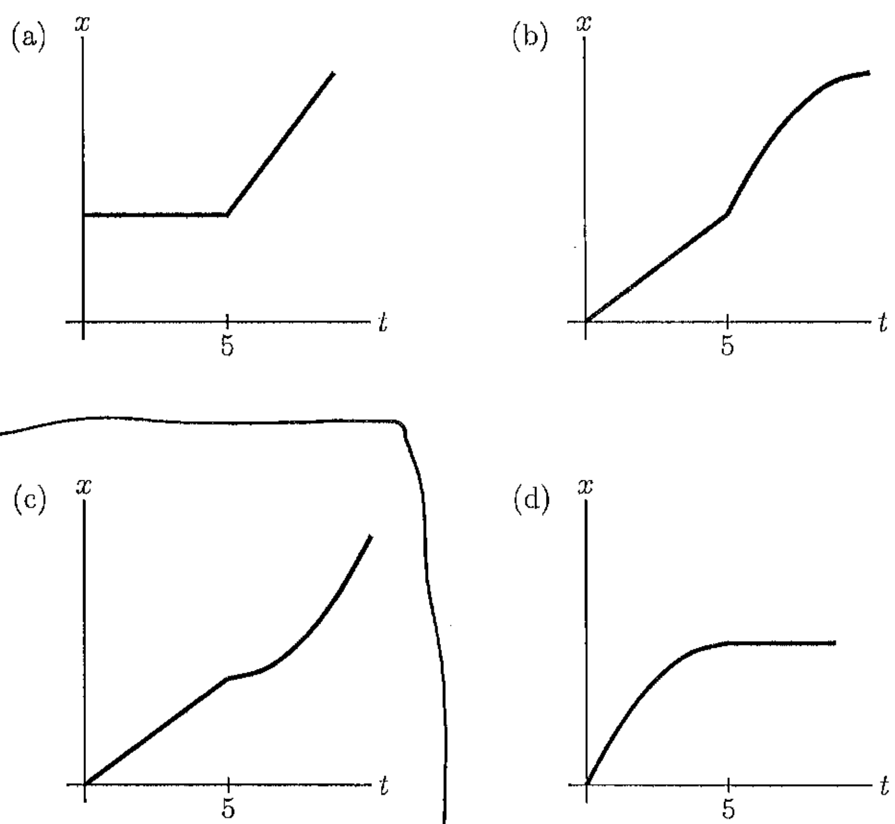
$V_0 = 20\,m/s,\ V = 0,\ a = -1.25\,m/s^2,\ X = ?,\ X_0 = 0$

$$V^2 = V_0^2 + 2a(X - \cancel{X_0}^{\,0}) \Rightarrow X = \frac{\cancel{V^2}^{\,0} - V_0^2}{2a} = \frac{-(20\,m/s)^2}{2(-1.25\,m/s^2)} = +160\,m$$

1. A car is traveling at $20.0\,m/s$ 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) $16\,m$	$\boxed{\text{(b) } 160\,m}$	(c) $320\,m$	(d) $480\,m$

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 gas and has a constant acceleration. Which of the following plots, correctly corresponds to his car's position versus time graph?

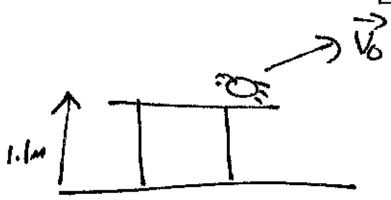


Constant velocity ⇒ a=0 ⇒ STRAIGHT Line x vs. t.

Const. Acceleration ⇒ parabola with INCREASING 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 37° angle. How far from the table does the grasshopper land (what horizontal distance) if we ignore air resistance?

(a) 206 m	(b) 25.8 m	$\boxed{\text{(c) } 20.6\,m}$	(d) 6.63 m



$\vec{V_0} = 14\,m/s$ at $37°$

$\Rightarrow V_{0,x} = 14\,m/s \cos 37° = 11.18\,m/s$

$V_{0,y} = 14\,m/s \sin 37° = 8.425\,m/s$

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

$X = X_0 + V_{0,x}t,\ y = y_0 + V_{0,y}t - \frac{1}{2}gt^2$ ← use y to find t then solve for x

$y = y_0 + V_{0,y}t - \frac{1}{2}gt^2 \Rightarrow 0 = 1.1\,m + 8.425\,m/s\,t - 4.9\,m/s^2\,t^2$

$\Rightarrow 4.9\,m/s^2\,t^2 - 8.425\,m/s\,t - 1.1\,m = 0 \quad \therefore t = \frac{8.425\,m/s \pm \sqrt{(8.425)^2 - 4(4.9)(-1.1)}}{2(4.9\,m/s^2)}$

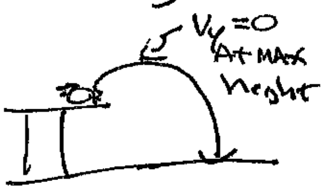
$= \frac{8.425\,m/s \pm \sqrt{92.54\,m^2/s^2}}{9.8\,m/s^2} = 1.8413\,s$ OR $\cancel{-.122\,s}$

$\therefore X = (11.18\,m/s)(1.8413\,s) = 20.5857\,m = 20.6\,m$

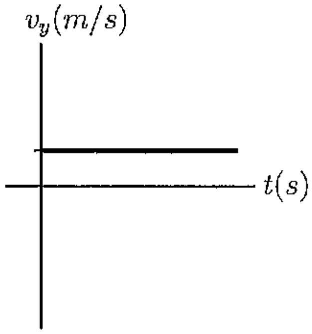
4. For the grasshopper of the previous problem, which of the following is the correct v_y vs. t graph for its motion?

$V_y = V_{0,y} - gt$

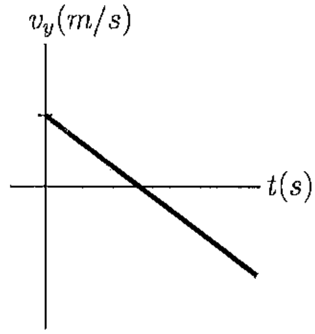
$\Rightarrow$ STRAIGHT LINE



(a)

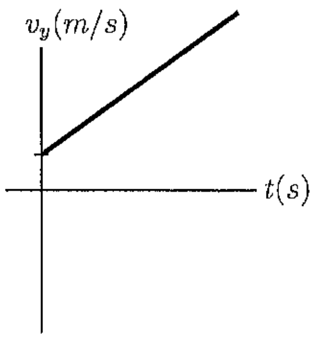


(b)

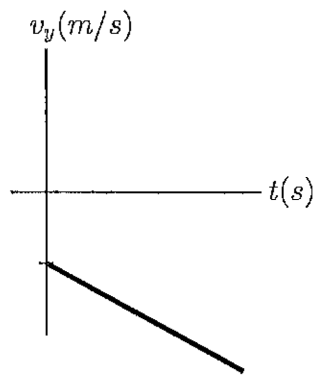


only graph with ZERO V_y

(c)

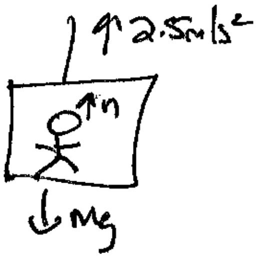


(d)



5. An 80-kg man is riding in an elevator that is accelerating upwards 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

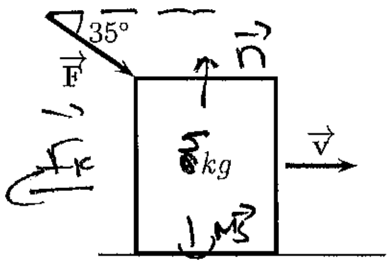


$n = ?$ $\quad \sum F_y = Ma_y. \quad a_y = 2.5\,m/s^2$

$n - Mg = Ma_y \Rightarrow n = Mg + Ma_y = M(g + a_y)$

$\Rightarrow n = 80\,kg\,(9.8\,m/s^2 + 2.5\,m/s^2) = 80\,kg\,(12.3\,m/s^2) = 984\,N$

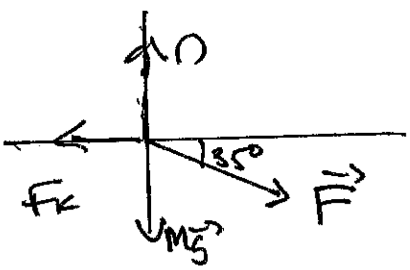
6. A 5.0 kg crate is being pushed across a horizontal floor by applying a force $F = 35\,N$, 35° below the horizontal. If the coefficient of kinetic friction between the mass and the floor is $\mu_k = 0.25$, what is the acceleration of the crate?



(a) $2.28\,m/s^2$	(b) $3.28\,m/s^2$
(c) $5.73\,m/s^2$	(d) $7.00\,m/s^2$

Forces: $\vec{n}$ up, $M\vec{g}$ Down, $\vec{f_K}$ to left ($f_K = \mu_K n$)

AND $\vec{F}$ at 35°



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

Motion to Right $\Rightarrow a_y = 0$. $a_x = a = ?$

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

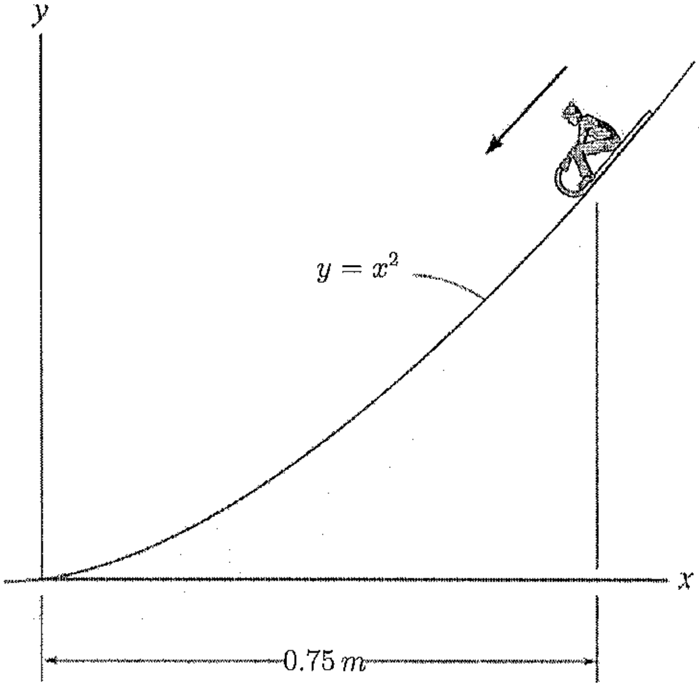
$\Rightarrow n = Mg + F\sin 35° = (5\,kg)(9.8\,m/s^2) + 35N \sin 35° = 69.08N$

$f_K = \mu_K n = .25(69.08N) = 17.27N$.

$\sum F_x = Ma_x \Rightarrow F\cos 35° - f_K = Ma \Rightarrow (35N)\cos 35° - 17.27N = 5kg\, a$

$\Rightarrow a = \frac{11.4N}{5kg} = 2.28\,m/s^2$

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 $x = 0.75\,m$, how fast will he be going at the bottom?



(a) $11.3\,m/s$	(b) $3.83\,m/s$
(c) $3.32\,m/s$	(d) Not enough information to determine

NO FRICTION ⇒

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

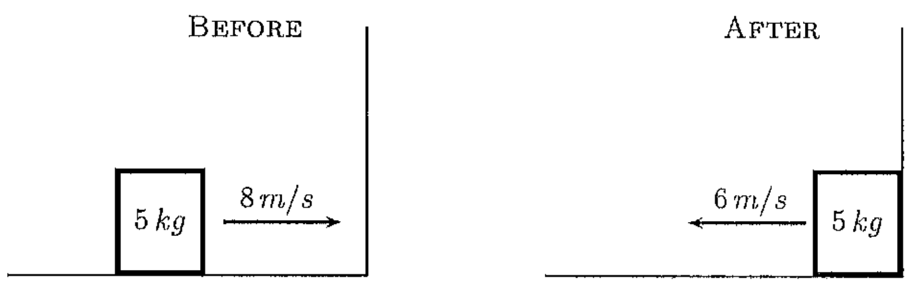
$V_1 = 0,\ y_1 = .75^2 = .5625m$

$V_2 = ?,\ y_2 = 0$

$\therefore\ Mgy_1 = \frac{1}{2}MV_2^2 \Rightarrow V_2 = \sqrt{2gy_1} = \sqrt{2(9.8m/s^2)(.5625m)}$

$\Rightarrow V_2 = 3.32m/s$

8. A 5.0-kg mass is sliding on a frictionless, horizontal surface going 8.0 m/s to the right when it hits a wall. If the mass bounces back with a speed of 6.0 m/s and the bounce time is 0.20 s, what is the magnitude and direction of the average force on the mass?



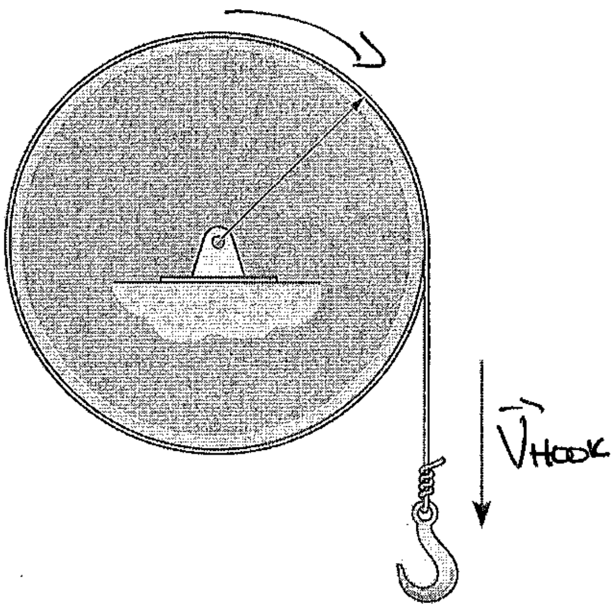
(a) 350 N to the right	$\boxed{\text{(b) 350 } N \text{ to the left}}$
(c) 50 N to the right	(d) 50 N to the left

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

$$V_{2,x} = -6\,m/s,\quad V_{1,x} = 8\,m/s \Rightarrow F_{AV,x} = \frac{5kg(-6m/s - 8m/s)}{.2s}$$

$$\Rightarrow F_{AV,x} = \frac{5kg(-14m/s)}{.2s} = -350N = 350N \text{ to left}$$

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?



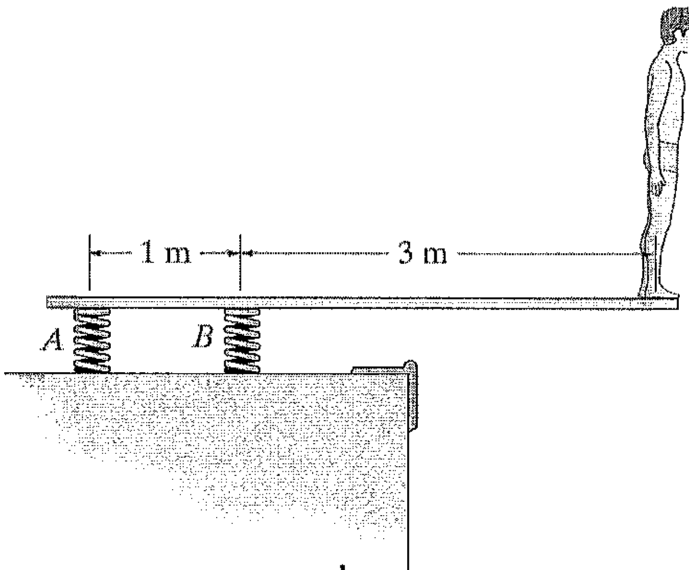
(a) *Down*
(b) *Up*
(c) $\odot$
$\boxed{\text{(d) } \otimes}$

As Hook Falls, Drum spins clockwise

RHR $\Rightarrow$ $\vec{\omega}$ is into page $= \otimes$

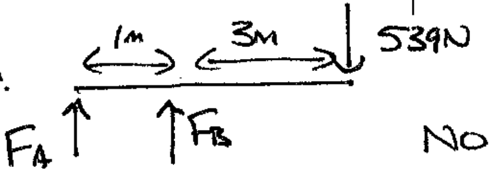
10. A 55 kg man stands on the edge of a diving board as shown. Two springs, one at A and the other at B, both exert vertical forces that keep the diving board (and man) horizontal and *prevent rotation.* How much force is the spring at B exerting? Assume the axis of rotation of the diving board is at A.

$W = Mg = (55\,kg)(9.8\,m/s^2) = 539N$



- $\boxed{\text{(a) } 2156\ N}$
- (b) 539 N
- (c) 220 N
- (d) 180 N

REAL FBD:



NO ROTATION $\Rightarrow \sum_i \tau = 0$

$\sum_i \tau = \tau_B - \tau_g$ Since F_A is at A $\Rightarrow$ No Torque

F_B tries to cause Counter-clockwise ROTATION, While Mg tries to cause clockwise.

$\sum_i \tau = 0 \Rightarrow \tau_B = \tau_g$. BOTH F_B AND Mg Vertical forces $\Rightarrow$

$\tau_B = X_B F_B$, $\tau_g = X_g Mg$. $X_B = 1m$, $X_g = 1m + 3m = 4m$. $\therefore (1m) F_B = (4m)(539N)$

$\Rightarrow F_B = 4(539N) = 2156N$. Note: $\sum_i F_y = 0$ since there is no motion

$\Rightarrow F_A + F_B - 539N = 0 \Rightarrow F_A = 539N - 2156N = -1617N \Rightarrow F_A$ Actually Down in Direction

11. On some alien planet, you find that a 0.34-m long simple pendulum has a period of 3.5 s, what is the acceleration due to gravity on that planet?

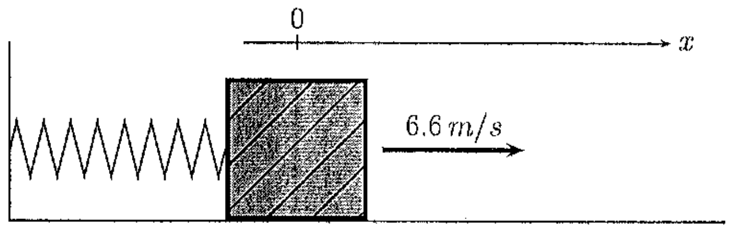
(a) $0.028\,m/s^2$	$\boxed{\text{(b) } 1.1\,m/s^2}$	(c) $4.2\,m/s^2$	(d) $9.8\,m/s^2$

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

$$T^2 = \frac{4\pi^2 L}{g} \Rightarrow g = \frac{4\pi^2 L}{T^2} = \frac{4\pi^2(.34m)}{(3.5s)^2} = 1.0957\,m/s^2$$

$$= 1.1\,m/s^2$$

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 $6.6\,m/s$ to the right. There is no friction between the mass and the floor. What is the phase angle, ϕ, in the equation $x = A\cos(\omega t + \phi)$ for this motion?



$X_0 = 0$

$V_0 = 6.6\,m/s$

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

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

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

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

V_0 is positive $\Rightarrow \sin\phi$ must be negative $\therefore\ \phi = -\pi/2$ rad

By the way, $6.6\,m/s = -\omega A\sin(-\pi/2) = \omega A$.

$\omega = \sqrt{\frac{k}{M}} = \sqrt{\frac{50\,N/m}{2\,kg}} = \sqrt{25} = 5\,rad/s \Rightarrow A = \frac{6.6\,m/s}{5\,rad/s} = 1.32\,m$

13. Your starship, *The Aimless Wanderer*, is in circular orbit around a 3.0×10^5-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 $3.5 \times 10^5\, m$, what is the acceleration due to gravity on the surface of planet Mongo?

ON ANY planet: $g = \frac{GM_M}{R_M^2}$ $\qquad M_M$ = MONGO'S MASS

R_M = MONGO'S RADIUS = $3\times10^5 m$

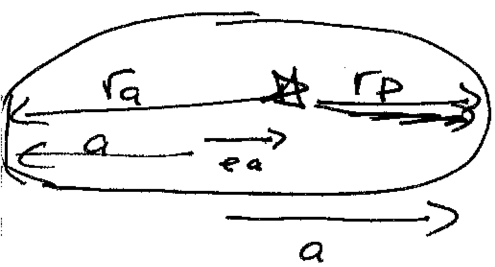
USE PERIOD to FIND M_M: $T = \frac{2\pi r^{3/2}}{\sqrt{GM_M}}$ $\qquad T = 30\,min \times \frac{60s}{min} = 1800s$

r = RADIUS OF ~~orbit~~ = $3.5\times10^5 m$

$$T^2 = \frac{4\pi^2 r^3}{GM_M} \Rightarrow M_M = \frac{4\pi^2 r^3}{GT^2} = \frac{4\pi^2 (3.5\times10^5 m)^3}{(6.67\times10^{-11} \frac{N\cdot m^2}{kg^2})(1800s)^2} = 7.83\times10^{21} kg$$

$$g = \frac{(6.67\times10^{-11} \frac{N\cdot m^2}{kg^2})(7.83\times10^{21} kg)}{(3\times10^5 m)^2} = 5.80 m/s^2$$

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 $\Rightarrow MV_a r_a = MV_p r_p$

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

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