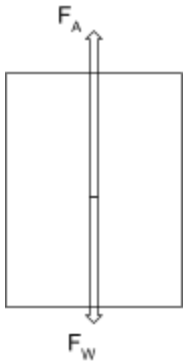
Sciduck's SSSS Hovercraft Answer Key

Use 2 significant figures unless stated otherwise.
Incorrect units will lead to a ½ point deduction.

Newton's Laws of Motion

1. B
2. 1.2m/s^2



F_A = 570N
F_W = 510N
m = F_W/g = 510N / 9.8m/s^2 = 52kg

$\Sigma F_{y\text{-direction}} = ma_y$
$\Sigma F_{y\text{-direction}} = F_A - F_w$
$a_y = (F_A - F_w)/m$ = (570N - 510N)/52kg = 1.2m/s^2

3. 5.9 m/s^2

$a=(g*F)/m=(F*w_2)/(m_1+m_2)=(m_2*g)/(m_1+m_2)$=3 kg*(9.8 m/s^2)/(2 kg+3 kg) = 5.9 m/s^2

4. A
5. 2.9 m/s^2

Vertical Portion

$\Sigma F_y = m*a_y = 0$ N
$\Sigma F_y = F_a*\sin 35 + F_n - F_w$
$0 = F_a*\sin 35 + F_n - F_w$
$F_N = F_W - F_A \sin 35$

Horizontal Portion

$\Sigma F_x = m*a_x$
$\Sigma F_x = F_a*\cos 35 - \mu_k*F_f$

Combined Portion

$m*a_x = F_a*\cos 35 - \mu_k(F_w - F_a*\sin 35)$
a_x = 150 N*cos35 - 2(280 N - 150 N*sin35)/(28.6 kg)
a_x = 2.9 m/s^2

Kinematics

6. Any correct answer

Ex. A ball changing directions at the top of it's trajectory

7. E

$\Delta y = v_0 t + \frac{1}{2} g t^2 = \frac{1}{2} g t^2$

$t = (2h/g)^{1/2}$

$d = vt = v*(2h/g)^{1/2} = (2hv^2/g)^{1/2}$

8. C

9. 56.6 m

$v_{y0} = 62.0 \text{m/s} * \sin(37) = 37.3 \text{ m/s}$

$v_{x0} = 62.0 \text{m/s} * \cos(37) = 49.5. \text{ m/s}$

$\Delta x = v_{x_0} t + \cancel{\frac{1}{2} a_x t^2}^{\,0}$

$t = \frac{\Delta x}{v_{x_0}} = \frac{273 \text{ m}}{49.5 \text{ m/s}} = 5.52 \text{s}$

$\Delta y = v_{y_0} t + \frac{1}{2} a_y t^2 = (37.3 \text{ m/s})(5.52 \text{ s}) + \frac{1}{2}(-9.8 \text{ m/s}^2)(5.52 \text{s})^2$

$= 56.6 \text{m}$

10. 52.3 m/s at -18.7°

(-½ point for missing or incorrect angle)

$a = \frac{v - v_0}{t}$

$v_y = v_{y_0} + a_y t$

$= 37.3 \text{ m/s} + (-9.8 \text{ m/s}^2)(5.52 \text{ s})$

$= -16.8 \text{ m/s}$

$v = \sqrt{v_y^2 + v_x^2} = \sqrt{(49.5 \text{ m/s})^2 + (-16.8 \text{ m/s})^2} = 52.3 \text{ m/s}$

$\tan\theta = \frac{-16.8 \text{ m/s}}{49.5 \text{ m/s}} \rightarrow \theta = -18.7$

Energy & Momentum

11. $v_0 = (m+M)/m*(2gh)^{1/2}$

(-½ pt for using wrong variables)

After Collision: Mechanical Energy is conserved

$\cancel{PE_0} + KE_0 = PE + \cancel{KE}^{\,\emptyset}$

$\frac{1}{2}(m+M)v'^2 = (m+M)gh$

$v' = \sqrt{2gh}$

Momentum is conserved during collision

$mv_0 + \emptyset = (m+M)v'$

$v_0 = \left(\frac{m+M}{m}\right)v'$

$\boxed{v_0 = \left(\frac{m+M}{m}\right)\sqrt{2gh}}$

12. -624650 J

(-½ point for flipped sign)

v = 110 km/h = 31 m/s

W = ΔKE = 1/2(m*v^2)-1/2(m*v_o^2) = -620,000 J

13. 61 m/s^2

KE + PE = KE' + PE'

PE = KE'

$mgh = ½mv^2$

$9.8m/s^2(190m) = ½v^2$

$v = 61\ m/s^2$

14. 3.3 m/s to the right

(-½ pt for wrong direction or negative; accept 3.3m/s for full credit)

$m_1v_1 + m_2v_2 = mv'$

$(5.0kg)(4.0m/s) + (3.0kg)(2.0m/s) = (5.0kg + 3.0kg)v'$

v'=3.3m/s

15. 19 J

Before: $KE_0 = ½(5.0kg)(4.0m/s)^2 + ½(3.0kg)(2.0m/s)^2 = 46J$

After: KE= $½(5.0kg)(3.3m/s)^2 = 27J$

KE_0 - KE = 46J - 27J = 19J

Fluid Mechanics

16. C

17. D

18. 77kg

(-½ pt for 78kg -- this rounding would make the mattress sink)

$F_W=F_B$

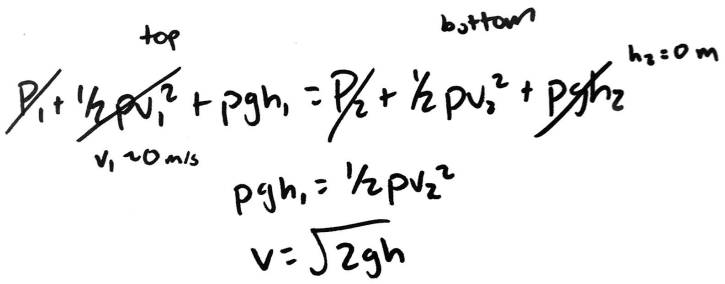
$Mg = \varrho_f gV$

$m=\varrho*lwh$

$m=1000kg/m^3(2.0m)(0.50m)(0.08m) = 80$ kg (mattress and extra weight)

Extra weight = 80kg - 2.3kg = 77.7 kg (round to 77kg)

19. v= 10. m/s



v=(2*9.8m/s^2*5.2m)^{½} = 10. m/s

20. 150,000 N/m^2

P_g=P-P_a and P=P_a+ϱgh

Pg=pgh = 1000kg/m^3(9.8m/s^2)(15m) = 150,000N/m^2

Design and History

21. Recirculating System
22. 1716
23. B, D, A, C
24. Zubr LCAC, Russia
25. June 2017