YUSO 2017 Hovercraft

Answer Key

Newton's laws of motion

1. b
2. d
3. *2 of these 3:* N • s, kg • m/s, momentum
4. Equal and opposite forces:

   $-((5\text{ kg} + 10\text{ kg})(-9.8\text{ m/s}^2)) =$ 147 N
5. Gravitational force/gravity:

   $(3\text{ kg})(-9.8\text{ m/s}^2) = 29.4\text{ N}$

   Normal force:

   $\cos(30^o)\ (29.4\text{ N}) = 25.5\text{ N}$

   Frictional force:

   $\sin(30^o)\ (29.4\text{ N}) = 14.7\text{ N}$

Kinematics

6. Horizontal *v* = 30 m/s

   Vertical *v*: $d = v_i t + \frac{1}{2}at^2$

   $20\ m = 0 + \frac{1}{2}(9.8\ m/s^2)t^2$, $t = 2.02$

   $d = \frac{v_i - v_f}{2}t$

   $20\ m = \frac{0 - v_f}{2}(2.02\ s)$, $v_f =$ *19.8 m/s*
7. c
8. d
9. $v_f^2 = v_i^2 + 2ad$

   $0 = \left(10\frac{m}{s}\right)^2 + 2\left(9.8\frac{m}{s^2}\right)d$, $d =$ 5.1 m
10. $v_f = v_i - at$

    $-10\frac{m}{s} = 20\frac{m}{s} - (9.8\frac{m}{s})t$, $t =$ 3.0 s

Kinetic Energy

11. $KE = \frac{1}{2}mv^2, m = mass, v = velocity$
12. vector, scalar (must get both)
13. d
14. Does this equality hold?

    $$\frac{1}{2}m_A v_{A,1}^2 = \frac{1}{2}m_B v_{B,2}^2$$

    $$\frac{1}{2}(35\ kg)\left(5\frac{m}{s}\right)^2 =? \frac{1}{2}(25\ kg)\left(7\frac{m}{s}\right)^2$$

    $$437.5\frac{kg \cdot m^2}{s^2} \neq 612.5\frac{kg \cdot m^2}{s^2}$$

    No, the collision is inelastic.
15. Conservation of momentum:

    $m_A v_{A,1} + m_B v_{B,1} = m_A v_{A,2} + m_B v_{B,2}$

$(25\ kg)\left(-5\frac{m}{s}\right) + (35\ kg)\left(3\frac{m}{s}\right) =$

$(25\ kg)v_{A,2} + (35\ kg)v_{B,2}$

OR

Conservation of KE: $\frac{1}{2}m_A v_{A,1}^2 +$

$\frac{1}{2}m_B v_{B,1}^2 = \frac{1}{2}m_A v_{A,2}^2 + \frac{1}{2}m_B v_{B,2}^2$

$(25\ kg)\left(-5\frac{m}{s}\right)^2 + (35\ kg)\left(3\frac{m}{s}\right)^2 =$

$(25\ kg)v_{A,2}^2 + (35\ kg)v_{B,2}^2$

Plug in $v_{A,2} = \frac{13}{3}m/s$ to either equation

to get $v_{B,2} = \boxed{-\frac{11}{3}m/s}$

Air-cushioned Vehicles

16. a
17. Provide a cushion of air on which the hovercraft rides
18. amphibious
19. d
20. Low gas mileage, Somewhat delicate skirt

    (Or other reasonable answers)

Fluid Mechanics

21. d
22. Since not fully submerged,

$$\rho_{cube}V_{cube} = \rho_{water}V_{water}$$

$$\rho_{cube}(0.5\ m)^3 = \left(1000\frac{kg}{m^3}\right)(0.1\ m^3)$$

$$\rho_{cube} = \boxed{800\frac{kg}{m^3}}$$

23. increases, temperature (must get both)
24. a
25. $\Delta P = \rho g(\Delta h)$: Hydrostatic pressure = density*gravity*height of fluid. Wells/water towers/dams, Braking systems, Hydraulic jack/press, Barometer (3 of the above 4, or other reasonable answers)