Hovercraft Test Division C Solutions Manual

Scoring:

- Multiple Choice - 1 point for correct answer
- Calculation: 3 points for correct answer, 1 point for correct units, and 1 point for correct significant figures
- Short Answer: 5 points for correct answer (partial credit may be given on graders' discretion)

Answers are correct to within 5%

1. 1.0×10^8 Pa (3-1-1: 3pts for answer, 1pt for units, 1pt for sig figs)
2. 0.6 s (3-1-1)
3. Chocolate Syrup (5pts no partial credit)
4. 0.50 N (3-1-1)
5. 7.3×10^{-3} m or 0.0073 m (3-1-1)
6. D (1pt)
7. 5.6 m/s (3-1-1)
8. 12 m (Half Credit for 9.7 m) (3-1-1)
9. Object: Sphere Speed Difference: 0.20 m/s (3-1-1 if object was correct, otherwise 0)
10. 0.62 rad/s (3-1-1)
11. 2 kg ball: 13.7 m/s left 5 kg ball: 4.28 m/s (or 4.29 m/s) right (3-1-1 for each)
12. Inertial mass is the m in $F = ma$; it measures how much an object resists acceleration - can be measured by applying a (nongravitational) force and measuring acceleration

    Gravitational mass is defined by the objects interaction with other masses through the gravitational field; it is the m in GMm/r^2 - can be measured by a balance

    (1pt for each definition, 1pt for each experiment, 1 extra if everything is correct - partial credit upon graders' discretion)
    Tiebreaker: Albert Einstein (Einstein is good enough)
13. Force: 4.50×10^3 N Height: 0.05 m (3-1-1 for each)
14. 59° (3-1-1)
15. B (1pt)
16. B (1pt)
17. C (1pt)
18. $\vec{F} = \frac{\Delta \vec{p}}{\Delta t}$ or $\vec{F} = \frac{d\vec{p}}{dt}$ (need vector signs for correct answer otherwise -2) (5pts)
19. Reaction Force: Your gravitation pull on the earth Strength: Same
    (2 points for each part, 1 extra if both correct)
20. 0.5 m (3-1-1)

Hovercraft Test Division C

All answers need to have the correct number of significant figures in SI units.

All answers must be on the answer sheet. No credit will be given for answers written on the test.

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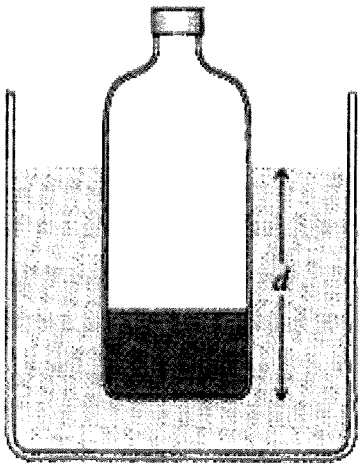
Use $g = 9.8\,\mathrm{m/s^2}$, $\rho_{\mathrm{water}} = 1000\,\mathrm{kg/m^3}$ for all questions unless otherwise stated.

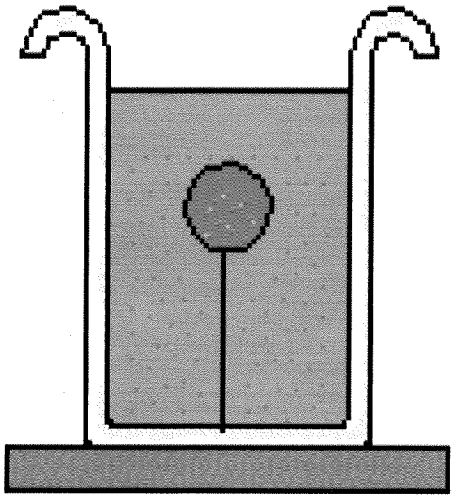
1. Assuming the density of saltwater is a constant $\rho = 1.03 \times 10^3\,\mathrm{kg\,m^{-3}}$, what is the pressure at a depth of 10 km below the surface of the ocean (use $P_{atm} = 101.325\,\mathrm{kPa}$)?
2. The bottle in the figure below is floating upright in a bucket of water. In equilibrium, the bottle is at a depth of $d_0 = 10\,\mathrm{cm}$. Find the period of oscillation assuming the bottle undergoes simple harmonic motion?



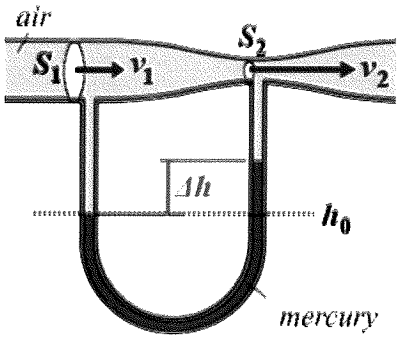
3. Suppose a fluid is flowing through a 10 m long pipe with radius 20 cm driven by a pressure differential of 125 Pa at a rate of 500 mL/s. What is the fluid?

Fluid	Viscosity Pa · s
blood (310 K)	$3 \times 10^{-3} - 4 \times 10^{-3}$
honey	$2 - 10$
molasses	$5 - 10$
chocolate syrup	$10 - 25$
molten chocolate	$45 - 130$
ketchup	$50 - 100$
lard	≈ 100
peanut butter	≈ 250
shortening	≈ 250

4. Suppose a ball (radius 2 cm) is tied to the bottom of a beaker filled with a fluid of density $\rho = 4200\,\text{kg/m}^3$ as shown in the figure below. If the beaker is then placed in an elevator accelerating upwards at $5\,\text{m/s}^2$, find the buoyant force on the ball (assume the ball is always completely submerged).

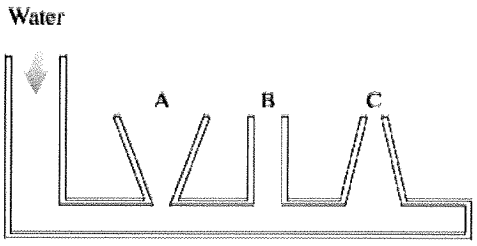


5. In the Venturi tube shown below, air with velocity 10 m/s and density 1.3 kg/m^3 enters from the left side. The radius of the tube at S_1 is 1.0 cm and the radius at S_2 is 0.5 cm. IF the U-tube contains mercury (density 13.600 kg/m^3, find the height difference Δh.



6. If water is poured into the contraption shown below and does not overflow, how do the water levels in tubes A, B, and C compare?

   (a) $d_A > d_B > d_C$
   (b) $d_B > d_A > d_C$
   (c) $d_C = d_A > d_B$
   (d) $d_A = d_B = d_C$
   (e) $d_C = d_B > d_A$

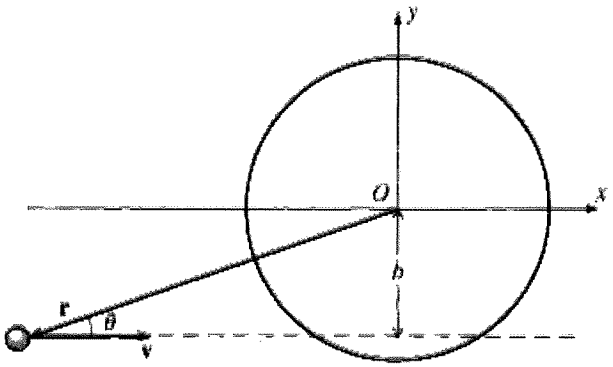


7. A spherical ball of radius 1.5 cm and density 2700 kg/m^3 is falling through olive oil (dynamic viscosity 0.081 Pa $\cdot$ s and density 930 kg/m^3). Assuming all given values are constant as the ball falls and that the fluid flow is laminar, find the terminal velocity of the ball.

8. Suppose the ball in the previous problem reaches terminal velocity v_T and is then accelerated to a velocity $2v_T$. It is then launched at an angle of 36° from the ground. How far will it travel (assume that air resistance is negligible)? - If you did not get an answer to the previous question, use $v_T = 5$ m/s for half-credit.

9. A solid sphere ($I = \frac{2}{5}MR^2$) and solid cylinder ($I = \frac{1}{2}MR^2$) both of mass 7 kg and diameter 20 cm roll without slipping down an inclined plane that is at an angle of 25° to the horizontal. The length of the inclined plane (hypotenuse) is 6 m. If both objects begin rolling from the top of the inclined plane at the same time, which object reaches the ground first, and how much faster is it moving than the other object?

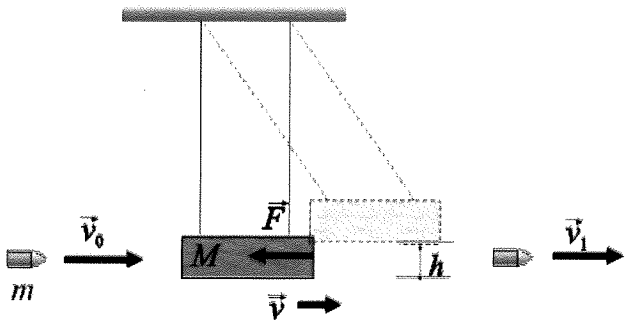
10. A uniform circular turntable (mass 8 kg, radius 20 cm, $I = \frac{1}{2}MR^2$) is at rest in the horizontal plane and is mounted on a frictionless axle, which lies along the vertical axis. A lump of putty (mass 100 g) with speed 6 m/s toward the edge of the turntable, so it approaches along a line that passes within a distance $b = 17$ cm of 0, as shown in the figure below. When the putty hits the turntable, it sticks to the edge, and the two rotate together with angular velocity ω. Find ω.



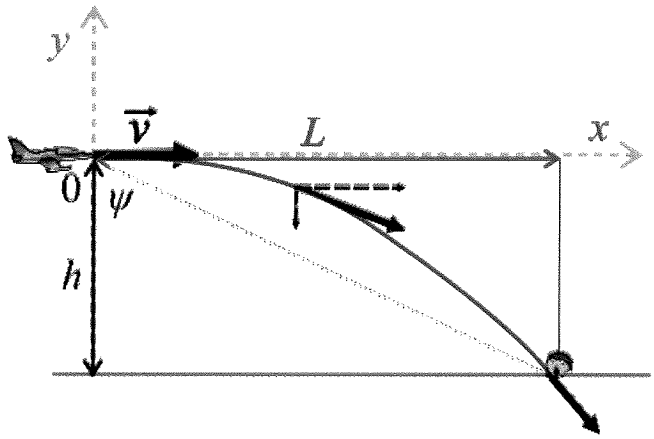
11. A 2.00 kg ball traveling at 12.0 m/s to the right collides with a 5.00 kg ball traveling at 6.00 m/s to the left. If the collision is perfectly elastic, find the final velocities of the two balls.

12. Describe the difference (in definition) between gravitational and inertial mass, and describe experiments that you could perform to determine the inertial mass and gravitational mass of an object. (Tiebreaker: who famously postulated that inertial mass and gravitational mass are actually the same?)

13. A rifle bullet with a mass $m = 5.00$ g is horizontally fired with a speed $v_0 = 750.0$ m/s into a ballistic pendulum with a mass $M = 3.00$ kg and a thickness $d = 30.0$ cm. The bullet goes through the pendulum and leaves it with a speed of $v_1 = 150.0$ m/s. Find the magnitude of the constant force that slows down the bullet inside the pendulum and the vertical height through which the pendulum rises.



14. A rescue plane flies to help a drowning man. The pilot keeps the plane at a constant height of 1000.0 m above the water surface and heads directly above the mans head (see the figure below). The speed of the plane is 420.0 km/h. At what angle of view (in degrees) must the pilot release the rescue bag in order to let it fall as close to the man as possible (assume air resistance is negligible)?

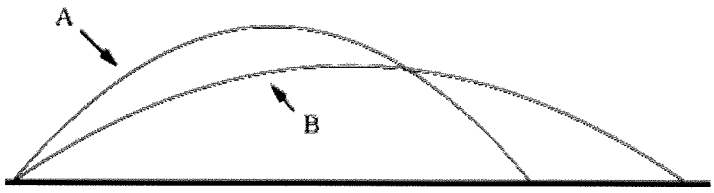


15. Suppose a projectile is launched at an angle θ between $0° < \theta < 90°$ from the horizontal. Which of the following is true about the velocity $\vec{v}$ and acceleration $\vec{a}$ of the projectile?

    (a) $|\vec{v}| = 0 = |\vec{a}|$
    (b) $\vec{v}_x > 0, \vec{v}_y = 0, |\vec{a}| = g$
    (c) $\vec{v}_x = 0, \vec{v}_y > 0, |\vec{a}| = g$
    (d) $\vec{v}_x > 0, \vec{v}_y = 0, |\vec{a}| = 0$
    (e) $\vec{v}_x > 0, \vec{v}_y > 0, |\vec{a}| > 0$

16. Shown below are the trajectories of two projectiles A and B. If both were launched at the same time with the same magnitude of initial velocity, which one hit the ground first (neglect air resistance)?

    (a) A
    (b) B
    (c) they hit at the same time



17. We can walk because the force of friction between the floor and our feet accelerates us. If a person with a mass of 70 kg walks without slipping 8 m on a wooden floor with coefficient of friction $\mu = 0.3$, what is the work done by friction?

    (a) 170N
    (b) 1600N
    (c) 0N
    (d) -1600N

18. State Newton's Second Law in terms of momentum.

19. What is the reaction force to the earth's gravitational pull on you, and how strong is it compared to the earth's gravitational pull on you?

20. A mass $m = 10\,\text{g}$ goes down an incline and onto a circular loop-the-loop of radius $r = 20\,\text{cm}$. What is the minimum height of the incline so that the mass can make it around the loop without falling off (assume all surfaces are frictionless)?