2017-18 Science Olympiad Invitational

Raisbeck Aviation High School
2 December 2017

Hovercraft Answer Sheet

Q	A	value
1.	A	+1
2.	D	+1
3.	F	+1
4.	T	+1
5.	B	+1
6.	B	+1
7.	C	+1
8.	B	+1
9.	A	+1
10.	A	+1
11.	D	+1
12.	C	+1
13.	C	+1

Q	A	value
14.	C	+1
15.	D	+1
16.	C	+2 TB1
17.	6×10^7 N	+2
18.	75 N	+2
19.	-32 N	+2
20.	-3630 N	+2
21.	2.6×10^6 N	+4 TB2
22.	250 m	+4
23.	2.5×10^5 J	+2
24.	800 N	+3
25.	540 N	+2
26.	3.0 m	+4 TB3

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SCIENCE OLYMPIAD INVITATIONAL

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HOVERCRAFT

Solutions

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1. Suppose you place a ball in the middle of a wagon that is at rest. When the wagon is pulled abruptly forward, which of the following correctly describes the motion of the ball immediately afterwards?

	Relative to wagon	**Relative to ground**
A	Goes to back of wagon	Stays still
B	Stays still	Goes forward
C	Goes to front of wagon	Goes forward
D	None of the above	

2. Newton's law of inertia states that no force is required to maintain motion. Why, then, do you have to keep pedaling your bicycle to maintain motion?
   A. Objects at rest tend to stay at rest.
   B. Objects in motion tend to stay in motion.
   C. Outside forces are balanced.
   D. None of the above.

Imagine an object that has only one force acting on it.

3. T or F It may have zero acceleration.
4. T or F It may have zero velocity.

5. When a high jumper leaves the ground, what is the dominant source of the upward force that accelerates her? What is the dominant force acts on her when she is in the air?

	Source of upward accelerating force	**Source of force in the air**
A	Ground	Air
B	Ground	Gravity
C	Legs	Gravity
D	Legs	Air

6. What impulse occurs when an average force of 10 N is exerted on a cart for 2.5 s?
   A. 4 kg m/s^3
   B. 25 kg m/s
   C. 63 kg m
   D. Impossible to determine from the information given.

A projectile is launched at an angle into the air. Neglecting air resistance,

7. what is its vertical acceleration?

	Vertical acceleration
A	Positive
B	Zero
C	Negative

8. What is its horizontal acceleration?

	Horizontal acceleration
A	Positive
B	Zero
C	Negative

9. Does a car speedometer measure speed, velocity, or both?
   A. Speed
   B. Velocity
   C. Both
   D. Neither

10. Can the velocity of an object be negative when its acceleration is positive?
   A. Yes
   B. No

11. What is the momentum of an 8-kg bowling ball rolling at 2 m/s?
   A. 16 N
   B. 4 kg s/m
   C. 64 kg^2 s/m
   D. None of the above

12. How does the force exerted by the ball on the pillow compare with the force the pillow exerts on the ball?
   A. $F_{ball} > F_{pillow}$
   B. $F_{ball} < F_{pillow}$
   C. $F_{ball} = F_{pillow}$
   D. Impossible to determine from the information given.

13. Why is it inaccurate to say that heavy objects sink and light objects float?
   A. "Heavy" and "light" are relative terms.
   B. Gravity affects heavy and light objects differently.
   C. Volume is relevant.

14. Compared with an empty ship, would a ship loaded a cargo of foam insulation float higher or lower?
    A. Higher
    B. No change
    C. Lower
    D. Not enough information given

15. A 0.5 m^3 cube just barely floats in water. What is the mass of the cube?
    A. 0.5 kg
    B. 5 kg
    C. 50 kg
    D. 500 kg

16. To measure viscosity, a thin layer of fluid is placed between two plates. One plate is stationary and the other is made to move. Which of the following physical properties of liquid do you NOT need to measure to calculate the coefficient of viscosity?
    A. Area of plates
    B. Velocity gradient
    C. Temperature of liquid
    D. Force required to move top plate

17. Calculate the force exerted on a rocket if the gases are expelled at a rate of 1500 kg/s with a speed of 4.0 x 10^4 m/s at the moment of take-off.
    $F = ma = \frac{m\Delta v}{t} = \left(1500\frac{kg}{s}\right)\left(4.0x10^4\frac{m}{s}\right) = 6\ x\ 10^7 N$

18. What force is need to accelerate a child on a sled (total mass = 60.0 kg) at 1.25 m/s/s?
    F = ma = (60.0 kg) (1.25 m/s /s) = 75 N

19. If an 8-kg bowling ball traveling at 2 m/s rolls into a pillow and stops in 0.5 s, calculate the average force it exerts on the pillow.
    $F = ma = m(v_f - v_i)/t$ = (8 kg)(0 m/s – 2 m/s) / 0.5 s = - 32 N

20. What is the average force required to stop an 1100-kg car in 8.0 seconds if the car is traveling at 95 km / h?
    Convert km / h to m/s: 95 km / h = 95000 m / 3600 s = 26.4 m/s
    $F = ma = m(v_f - v_i)/t$ = (1,100 kg) (0 m/s – 26.4 m/s) / 8.0 s = -3630 N

21. A bathyscaph descends to the bottom of the Mariana Trench, 11,000 m deep. How much force is exerted by the water on an observation window with a diameter of 16 cm? Assume the density of salt water is 1030 kg/m^3.

$$F = PA = \rho ghA = \left(1030\frac{kg}{m^3}\right)\left(\frac{10\frac{m}{s}}{s}\right)(11{,}000\ m)(\pi)(0.08\ m)^2 = 2.6\ x\ 10^6 N$$

22. A shiny new sports car sits in the parking lot of a car dealership. Above is a cargo plan, flying horizontally at 50 m/s. At the exact moment that the plane is 125 m directly above the car, a heavy crate accidentally falls from its cargo doors. Relative to the car, where the crate hit?

$d = v_{ave}t$

Find t: $d = v_{ave}t$ where $v_{ave} = \frac{vf+vi}{2}$ and $v_f = at + v_i$

So $t = \sqrt{\frac{2d}{a}}$

$$d = \left(50\frac{m}{s}\right)\sqrt{\frac{(2)(125\ m)}{10\frac{m}{s^2}}} = 250\ m$$

23. How much net work is required to speed up a 1,000-kg car from 20 m/s to 30 m/s?

$$W = \Delta KE = KE_2 - KE_2 = \frac{1}{2}m(v_2^2 - v_1^2) = \frac{1}{2}(1000\ kg)\left[\left(30\frac{m}{s}\right)^2 - \left(20\frac{m}{s}\right)^2\right] = 2.5\ x\ 10^5 J$$

24. For a top tennis player, the ball may leave the racket on a serve with a speed of 55 m/s (~120 mph). If the ball has a mass of 0.060 kg and is in contact with the ball for 4 x 10^{-3} s, estimate the average force on the ball.

$$F = \frac{m\Delta v}{t} = \frac{(0.060\ kg)\left(55\frac{m}{s}\right)}{4\ x10^{-3}s} = 800\ N$$

Imagine an acrobat leaps from some height.

25. What impulse is exerted on the feet of a 70-kg person who hits the ground at a speed of 7.7 m/s?

$$\Delta p = m\Delta v = (70\ kg)\left(7.7\frac{m}{s}\right) = 540\ N\ s$$

26. Assuming no friction, from what height did the person drop?

$d = v_{ave}t$

@ $v_i = 0\ m/s$, where $v_{ave} = \frac{v_f}{2}$ and where $a = \frac{v_f - v_i}{t}$, so $t = \frac{v_f}{a}$

So,

$$d = \left(\frac{v_f}{2}\right)\left(\frac{v_f}{a}\right) = \frac{\left(7.7\frac{\text{m}}{\text{s}}\right)^2}{2 * 9.8\frac{\text{m/s}}{\text{s}}} = 3.0\ \text{m}$$