

YUSO 2017 Hovercraft

Exam Questions

You have 20 minutes to complete this exam. Please use metric units and appropriate sig figs. Assume gravitational acceleration $g = -9.8 \text{ m/s}^2$ and no friction or air resistance. Do not write on this sheet.

Newton's laws of motion

1. An object at rest stays at rest unless acted upon by a(n) _____ force.
 - a. Equal and opposite
 - b. Unbalanced
 - c. Frictional
 - d. Centripetal
2. Which of the following is not a contact force?
 - a. Air resistance force
 - b. Normal force
 - c. Frictional force
 - d. Gravitational force
3. Impulse has units of _____ and is dimensionally equivalent to _____.
4. A 5 kg box is stacked on a 10 kg box. What is the force exerted by the floor on the 10 kg box?
5. A 3 kg box is placed on a ramp with an incline 30 degrees from horizontal, where it remains stationary. Draw a force diagram, naming and quantifying the forces acting on the box which keep it in equilibrium.

Kinematics

6. A ball is thrown off a 20 m cliff with horizontal velocity of 30 m/s and vertical velocity 0 m/s.
What is the projectile's horizontal and vertical velocity when it hits the ground?
- For questions 7 and 8, a projectile is thrown off a cliff at 45 degrees from the horizontal (i.e. it goes up before it goes down).
7. **At what point in the projectile's trajectory is its speed greatest?**
 - a. Immediately after being thrown
 - b. At the highest point
 - c. Immediately before landing
 - d. None of the above
 8. **At what point in the projectile's trajectory is its acceleration greatest?**
 - a. Immediately after being thrown
 - b. At the highest point
 - c. Immediately before landing
 - d. None of the above
 9. A ball is thrown straight up with $v = 10 \text{ m/s}$. At what height will it reach $v = 0 \text{ m/s}$?
 10. The ball is thrown straight up again with $v = 20 \text{ m/s}$. At what time will it reach $v = -10 \text{ m/s}$?

Kinetic energy

11. Write the basic equation for kinetic energy of an object as a function of its velocity.
12. Choose one of the underlined terms for each: Momentum is a (scalar/vector) quantity and kinetic energy is a (scalar/vector) quantity.

13. For an object to have momentum, it must have nonzero
- Mass and velocity
 - Mass and potential energy
 - Kinetic energy
 - a. and c.
14. A 25 kg bumper car, at rest, is bumped by a 35 kg bumper car traveling at 5 m/s. Directly after the collision, the velocity of the first car is 7 m/s and the second car comes to a complete stop. Is this an elastic collision (i.e. is kinetic energy conserved)? Show work.
15. The driver of the 25 kg bumper car retaliates by bumping the 35 kg car, which is now travelling at 3 m/s *towards* the 25 kg car, *head-on* at 5 m/s. If after the collision, the resultant velocity of the 25 kg car is $v = \frac{13}{3}$ m/s, what is the resultant velocity of the 35 kg car? Assume this collision is elastic (both momentum and kinetic energy are conserved). Show work.

Air-cushioned vehicles

16. The concept of the modern hovercraft was developed by
- Christopher Cockerell
 - Alvis Leonides
 - Cecil Latimer-Needham
 - Jean Bertin
17. Describe the purpose of the skirt of a hovercraft.
18. Hovercraft are used as _____ vehicles, able to travel across both land and water.
19. In recent times, hovercraft have been used for
- Military services
 - Recreational racing
 - Rescue work
 - All of the above
20. List two downfalls of traditional hovercraft design which limit its applicability or usefulness.

Fluid mechanics

21. For several equal-volume balls, the ball made of which material feels the largest buoyant force?
- Styrofoam
 - Wood
 - Lead
 - All feel the same force
22. A cube with side length $l = 0.5$ m displaces 0.1 m^3 of water ($\rho = 1000 \text{ kg/m}^3$) when dropped in a large pool. What is its density?
23. Choose one of the underlined terms for each: Viscosity of a gas (increases/decreases) with increasing (pressure/temperature).
24. Which of the following must be true for the basic Bernoulli's equation to apply?
- Fluid velocity must be constant
 - The fluid must be compressible
 - The fluid must be viscous
 - All of the above
25. State Pascal's law, labeling all variables. List three practical applications in which this law is clearly in action.