UNAM
UNIVERSITY OF NAMIBIA

Faculty	:	Agriculture, Engineering and Natural Sciences			
School	:	Science			
Department	:	Physics, Chemistry and Material Science			
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Duration	:	3 hours	Full Marks	:	100

FIRST OPPORTUNITY EXAMINATION QUESTIONS

Lecturer(s)/Examiner(s) : Mr. K. P. Shiningayamwe, Main Campus
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This question paper consists of 4 pages of questions excluding this front page and the last page of the list of universal constants.

INSTRUCTIONS:

- Answer **ALL** questions in the provided examination answer book.
- Clearly, label the question numbers in your answer book(s).
- Clearly and completely provide your surname and student number on all answer books used.
- Some universal constants that may be useful are listed at the end.
- Demonstrate understanding by showing all your work, including diagrams.
- Please denote vectors in hand written answers with *arrows* above symbols.
- A calculator may be used.

UNIVERSITY OF NAMIBIA EXAMINATIONS

Answer all questions.

Section A

Total: 54

1. If $\vec{A} = (3.00\hat{i} - 4.00\hat{j} + 5.00\hat{k})$ and $\vec{B} = (4.00\hat{i} + 3.00\hat{j} - 2.00\hat{k})$, find the angle between $\vec{A}$ and $\vec{B}$ using the dot product. (5)

2. A batter hits a baseball so that it leaves the bat at speed $v_0 = 37.0\text{m/s}$ at an angle $\alpha_0 = 53.1°$. Neglect air resistance. (11)

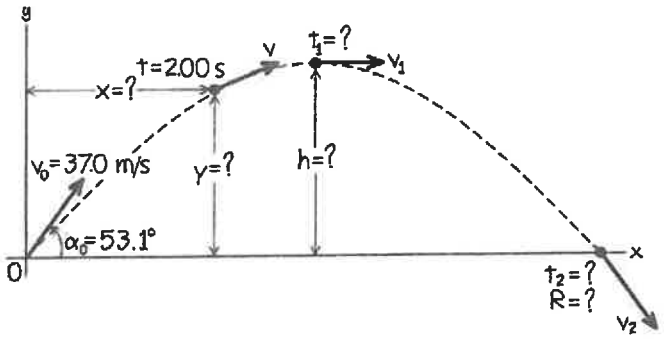


Figure 1: The baseball's trajectory

2.1. Explain why horizontal velocity remains constant in projectile motion. [2]

2.2. Find the velocity (magnitude and direction) of the ball at $t = 2.00\text{s}$. [5]

2.3. Find the time when the ball hits the ground. [4]

3. Explain the difference between static and kinetic friction. (2)

4. A sled with a mass of 25.0 kg rests on a horizontal sheet of essentially frictionless ice. It is attached by a 5.00 m rope to a post set in the ice. Once given a push, the sled revolves uniformly in a circle around the post. The sled makes five complete revolutions every minute. (5)

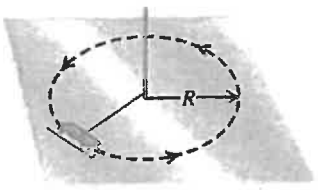


Figure 2: The sled revolving uniformly in a circle around the post.

4.1. What is the radial acceleration of the sled? [3]

4.2. Find the force F exerted on the sled by the rope. [2]

5. A box of mass $m = 10$ kg is initially at rest on a rough horizontal surface, where the coefficient of kinetic friction between the box and the surface is $\mu_k = 0.2$. The box is then pulled horizontally by a force $F = 50$ N that makes an angle $\theta = 60°$ with the horizontal. (15)

5.1. Draw a free body diagram. [3]

5.2. Find the acceleration of the box [3]

5.3. Assuming constant acceleration of $a = 1.406\text{m/s}^2$, use kinematics to find speed v_f of the box after it moves a distance s of 4 m. [3]

5.4. Find the work done by the applied force $F = 50N$ over a distance of 4.0m. [3]

5.5. If the work done by the applied horizontal force is 100J, and work done by frictional force is -43.76J, use the work-kinetic energy theorem to find the final speed v_f of the box after it moves a distance s of 4 m. [3]

6. You throw a ball with a mass of 0.40 kg against a brick wall. It is moving horizontally to the left at 30m/s when it hits the wall; it rebounds horizontally to the right at 20m/s. (5)

6.1. Find the impulse of the net external force on the ball during its collision with the wall. [3]

6.2. If the ball is in contact with the wall for 0.010 s, find the average horizontal force that the wall exerts on the ball during the impact. [2]

7. The angular position θ of a 0.36-m-diameter flywheel is given by $\theta = (2.0\text{rad/s}^3)\text{t}^3$. (6)

7.1. Find the average angular velocity, in rad/s and in rev/min, over the interval $t_1 = 2.0$s to $t_2 = 5.0$s. [3]

7.2. Find the instantaneous angular velocities at $t_1 = 2.0$s and $t_2 = 5.0$s. [3]

8. To loosen a pipe fitting, a plumber slips a piece of scrap pipe (a cheater) over his wrench handle. He stands on the end of the cheater, applying his 900 N weight at a point 0.80 m from the center of the fitting (figure 3). The wrench handle and cheater make an angle of 19° with the horizontal. Find the magnitude and direction of the torque he applies about the center of the fitting. (5)

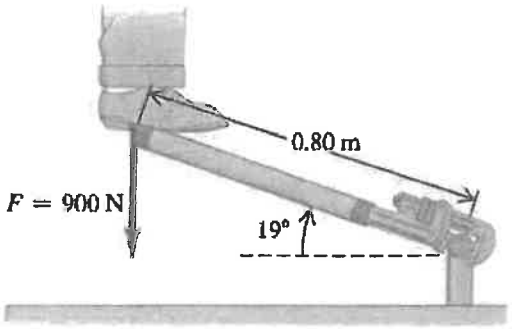


Figure 3: Applying torque with an extended wrench

Section B Total: 54

9. State two conditions for an object to be in equilibrium. (4)

10. Write the following mathematical equations: Continuity equation for an incompressible fluid and Bernoullis equation for an ideal, incompressible fluid. (4)

11. Three men went to the moon in a shell fired from a giant cannon sunk in the earth in Florida. Neglect air resistance, the earths rotation, and the gravitational pull of the moon. The earth's radius and mass are $R_E = 6.38 \times 10^6$ m and $m_E = 5.97 \times 10^{24}$ kg, respectively. (10)

    11.1. Find the minimum muzzle speed needed to shoot a shell straight up to a height above the earth equal to the earth's radius. [5]

    11.2. Find the minimum muzzle speed that would allow a shell to escape from the earth completely (the escape speed). [5]

12. An ultrasonic transducer used for medical diagnosis oscillates at 6.7MHz = 6.7×10^6Hz. How long does each oscillation take, and what is the angular frequency? (6)

13. Explain what is meant by a mechanical wave and describe the two main types of mechanical waves. (4)

14. A ship (figure 4) uses a sonar system to locate underwater objects. The density, ρ, of water is 1.00×10^3kg/m^3 and the bulk modulus, B, of water is 2.18×10^9Pa. (6)

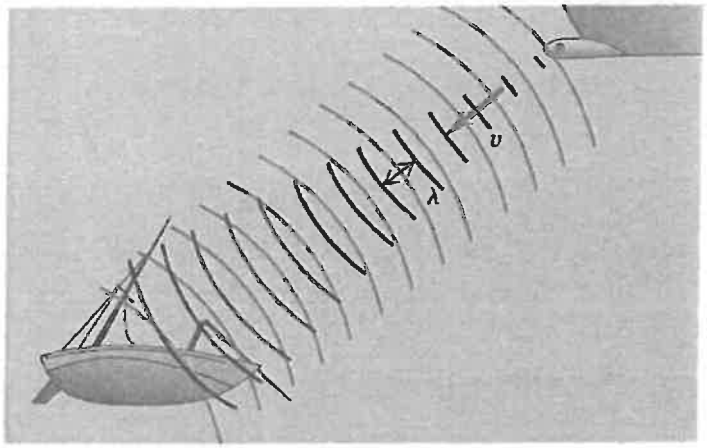


Figure 4: A ship using sonar system

    14.1. Find the speed of sound waves in water. [3]

    14.2. Find the wavelength of a 262 Hz wave. [3]

15. A metal rod of length 0.50m is heated from 15°C to 95°C. The length of the rod increases by 0.96mm. What is the coefficient of linear expansion for the rod? (4)

16. Calculate the minimum amount of energy, in joules, required to completely melt 130 g of silver initially at 15.0°C. The heat of fusion for silver is $L_F = 105 \times 10^3$ J/kg. (6)

17. As an ideal gas undergoes an *isothermal* (constant-temperature) expansion at temperature T, its volume changes from V_1 to V_2. Show that the work done by the gas, $W = nRT \ln \frac{V_1}{V_2} = nRT \ln \frac{p_1}{p_2}$. (6)

18. A hot cup of coffee is left on a table and cools down to room temperature. Define an irreversible process and explain why the cooling of the coffee is an example of such a process. (4)

Total available marks: 108
Full marks: 100

Some useful constants

Elementary charge:	$e = 1.602 \times 10^{-19}$ C
Mass of the electron:	$m_e = 9.11 \times 10^{-31}$ kg
Mass of the proton:	$m_p = 1.67 \times 10^{-27}$ kg
Mass of the neutron:	$m_n = 1.67 \times 10^{-27}$ kg
Atomic mass unit:	$1u = 1.6605 \times 10^{-27}$ kg
Avogadro's number:	$N_A = 6.02 \times 10^{23}$ atoms/mol
Permittivity of free space:	$\epsilon_0 = 8.85 \times 10^{-12}$ C^2/N $\cdot$ m^{-2} $= 8.85 \times 10^{-12}$ F/m
Permeability of free space:	$\mu_0 = 4\pi \times 10^{-7}$ T $\cdot$ m/A
Coulomb's constant:	$k = 8.99 \times 10^9$ N $\cdot$ m^2/C^2
Gravitational constant:	$G = 6.67 \times 10^{-11}$ N $\cdot$ m^2 $\cdot$ kg^{-2}
Speed of light in vacuum:	$c = 3.00 \times 10^8$ m $\cdot$ s^{-1}
Electron volt:	1 eV $= 1.602 \times 10^{-19}$ J
Magnetic field strength (gauss):	1 G $= 10^{-4}$T
Free-fall acceleration:	g $= 9.80$ m/s^2
Earth's mass:	$m_E = 5.97 \times 10^{24}$ kg
Earth's radius	$R_E = 6.37 \times 10^6$ m
Mass of the Sun	$M_\odot = 1.989 \times 10^{30}$kg
Distance from Earth to the Sun	$R_{E\text{-}S} = 1.50 \times 10^{11}$m
Air density:	$\rho_{air} = 1.225$ kg/m^3