Course Code：H0180111

Final Examination Paper for University Physics I

Spring 2019, Beijing Institute of Technology

Paper A

9:30-11:30 June 26, 2019

Class（Major）_____Student ID_____Name_____

Multiple Choice	Completion	Problems	Total Score

Universal Gas Constant R=8.31 $J\cdot mol^{-1}\cdot K^{-1}$ Boltzmann's Constant $k=1.38\times10^{-23}J\cdot K^{-1}$

1. Multiple Choice (2 points for each, 16 points in total)

1-1 Which of the following statements cannot be true?
(A) An object has a northward velocity and a southward acceleration.
(B) An object has a varying velocity while its speed is constant.
(C) An object is increasing speed as its acceleration decreases.
(D) An object has a varying speed while its velocity is constant.

1-2 Suppose a car moves at constant speed along a mountain road. At which of the following places does it exert the greatest force on the road?
(A) at the top of a hill.
(B) at a dip between two hills.
(C) on a level stretch near the bottom of a hill.

1-3 Which of the following statements about work is not true.
(A) The normal force on an object can never do work.
(B) Centripetal force never does work.
(C) The work done by a kinetic friction force is always negative.
(D) The work done by a static friction force is always zero.

1-4 Consider two observers who are in different inertial reference frames that move with velocity v with respect to each other. They both observe an object being pulled on a rough horizontal surface. They agree as to the value of
(A) the objects kinetic energy.
(B) the total work done on the object.
(C) the amount of energy transformed from mechanical to thermal energy due to friction.
(D) the objects momentum.

1-5 Two solid spheres simultaneously start rolling from rest down an incline. One sphere has twice the radius and twice the mass of the other (m1 = 2m2, R1 = 2R2).
(A) Sphere 1 reaches the bottom of the incline first.
(B) Sphere 2 reaches the bottom of the incline first.
(C) Sphere 2 has a greater speed at the bottom of the incline.
(D) Sphere 1 has a greater total kinetic energy at the bottom.

1-6 Which of the following statements is true?
(A) If a force on an object is zero, the torque is also zero.
(B) If a torque on an object is zero, the force is zero.
(C) If the net force on a system is zero, the net torque is also zero.
(D) If the net torque on a system is zero, the net force is zero.

1-7 An ideal monatomic gas is allowed to expand slowly to twice its volume (1) isothermally; (2) adiabatically; (3) isobarically.
(A) The change in internal energy is the greatest in isothermal process.
(B) The change in internal energy is the least in isothermal process.
(C) The heat added to the gas is the greatest in adiabatic process.
(D) The heat given out by the gas is the greatest in isothermal process.

1-8 Two hollow cylinders have the same inner and outer radii and the same mass, but they have different lengths. One is made of low-density wood and the other of high-density lead. Which cylinder has the greater rotational inertia around its axis of symmetry?
(A) the wood cylinder;
(B) the lead cylinder;
(C) the two rotational inertia are equal.

2. Completion (3 points for each, 24 points in total)

2-1 A helicopter rotor has four blades, each 3.4 m long from the central shaft to the blade tip. The rotor rotates at 550 rev/min in a test. What is the radial acceleration of the blade tip in m/s^2?

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2-2 In an experiment, one of the forces exerted on a proton is $\vec{F} = -\alpha x^2 \vec{i}$, where α=12 N/m^2. How much work does $\vec{F}$ do when the proton moves along the straight-line path from the point (0.10 m, 0) to the point (0.30 m, 0)? _____

2-3 A 1050-kg sports car is moving westbound at 15.0 m/s on a level road when it collides with a 6320-kg truck driving east on the same road at 10.0 m/s. The two vehicles remain locked together after the collision. What is the velocity (magnitude and direction) of the two vehicles just after the collision?_____

2-4 A baseball has mass 0.145 kg. The velocity of a pitched ball has a magnitude of 45.0 m/s and the batted ball's velocity is 55.0 m/s in the opposite direction. If the ball remains in contact with the bat for 2.00 ms, what is the magnitude of the average force applied by the bat?_____

2-5 A computer disk drive is turned on starting from rest and has constant angular acceleration. If it took 0.750 s for the drive to make its second complete revolution, what is its angular acceleration in rad/s^2?_____

2-6 Modern vacuum pumps make it easy to attain pressures of the order of 10^{-13} atm in the laboratory. At a pressure of 9.00×10^{-14} atm and an ordinary temperature of 300.0 K, how many molecules are present in a volume of 1.00 cm^3?_____

2-7 A heat pump operates as an air conditioner between the temperatures of 24 °C and 38 °C. If its coefficient of performance is 24% of that of a Carnot engine, what is the effective coefficient of performance?_____

2-8 light of wavelength 690 nm passes through two narrow slits 0.60 mm apart. The screen is 1.50 m away. A second source of unknown wavelength produces its second-order fringe 1.13 mm closer to the central maximum than the 690-nm light. What is the wavelength of the unknown light?

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3. Problems (10 points for each, 60 points in total)

3-1 A rocket is fired at an angle from the top of a tower of height h_0 = 50.0 m. Because of the design of the engines, its position coordinates are of the form $x(t) = A + Bt^2$ and $y(t) = C + Dt^3$, where *A*, *B*, *C,* and *D* are constants. Furthermore, the acceleration of the rocket 1.00 s after firing is $\vec{a} = (4.00\vec{\imath} + 3.00\vec{\jmath})$ m/s^2. Take the origin of coordinates to be at the base of the tower. (a) Find the constants *A, B, C,* and *D*, including their SI units. (b) At the instant after the rocket is fired, what are its acceleration vector and its velocity? (c) What are the x- an y-components of the rocket's velocity 10.0 s after it is fired, and how fast is it moving? (d) What is the position vector of the rocket 10.0 s after it is fired?

3-2 A sphere and a cylinder have the same radius and the same mass. They start from rest at the top of an incline. (a) Which has the greater speed at the bottom? (b) Which has the greater total kinetic energy at the bottom? (c) Which has the greater rotational kinetic energy? Calculate and explain.

3-3 (a) What is the total random translational kinetic energy of 5.00 L of hydrogen gas (molar mass 2.016 g/mol) with pressure 1.01×10^5 Pa and temperature 300 K? (b) If the tank containing the gas is placed on a swift jet moving at 300.0 m/s, by what percentage is the total kinetic energy of the gas increased? (c) Since the kinetic energy of the gas molecules is greater when it is on the jet, does this mean that its temperature has gone up? Explain.

3-4 A 1.00-mol sample of an ideal monatomic gas, originally at a pressure of 1.00 atm, undergoes a three-step process: (1) it is expanded adiabatically from $T_1 = 550$ K to $T_2 = 389$ K; (2) it is compressed at constant pressure until its temperature reaches T_3; (3) it then returns to its pressure and temperature by a constant volume process. (a) Plot these processes on a PV diagram. (b) Determine T_3. (c) Calculate the change in internal energy, the work done by the gas, and the heat added to the gas for each process, and (d) for the complete cycle.

3-5 Transverse waves on a string have wave speed 8.00 m/s, amplitude 0.070 m, and wavelength 0.320 m. The waves travel in the $-x$ direction, and at $t = 0$ the $x = 0$ end of the string has its maximum upward displacement. (a) Find the frequency and period of these waves. (b) Write a wave function describing the wave. (c) Find the transverse displacement of a particle a $x = 0.360$ m at time $t = 0.150$ s. (d) How much time must elapse from the instant in part (c) until the particle at $x = 0.360$ m next has maximum upward displacement?

3-6 What is the non-zero minimum thickness for the air layer between two flat glass surfaces if the glass is to appear bright when 640-nm light is incident normally? What if the glass is to appear dark?