

※將答案寫出即可，並於答案卷上依序作答，請註明作答之大題及其題號。

1. A boy whirls a stone in a horizontal circle of radius 1.5 m and at height 2.0 m above level ground. The string breaks, and the stone flies off horizontally and strikes the ground after traveling a horizontal distance of 10 m. What are
  - (a) the magnitude of the centripetal acceleration of the stone during the circular motion? {5%}
  - (b) the speed of the stone when it strikes the ground? {5%}
2.
  - (a) A hot-air balloon of mass  $M$  is descending vertically with downward acceleration of magnitude  $a$ . How much mass must be thrown out to give the balloon an upward acceleration of magnitude  $a$ ? {5%} (Assume that the upward force from the air does not change because of the decrease of the mass)
  - (b) A 1000 kg boat is traveling at 90 km/h when its engine is shut off. The magnitude of the frictional force between the boat and the water is proportional to the speed  $v$  of the boat as  $f_k = 70v$ , where  $v$  is in m/s and  $f_k$  is in newtons. Find the time required for the boat to slow to 45 km/h. {5%}
3. A uniform ball, of mass  $M = 6.00$  kg and radius  $R$ , rolls smoothly from rest down a ramp at angle  $\theta = 30.0^\circ$ . The ball descends a vertical height  $h = 1.20$  m to reach the bottom of the ramp. What are
  - (a) the speed of the ball at the bottom? {5%} and
  - (b) the magnitude of the frictional force on the ball? {5%}
4. A pulley, with a rotational inertia of  $1.0 \times 10^{-3} \text{ kg} \cdot \text{m}^2$  about its axle and a radius of 10 cm, is acted on by a force applied tangentially at its rim. The force varies in time as  $F = 0.50t + 0.30t^2$ , with force in newtons and  $t$  in seconds. The pulley is initially at rest. At  $t = 3.0$  s what are
  - (a) its angular acceleration {5%} and
  - (b) its angular speed? {5%}
5.
  - (a) Particle A and particle B are held together with a compressed spring between them. When they are released, the spring pushes them apart, and they then fly off in opposite directions, free of the spring. The mass of A is 2.00 times the mass of B, and the energy stored in the spring was 60 J. Assume that the spring has negligible mass and that all its stored energy is transferred to the particles. Once the transfer is completed, what is the kinetic energy of particle A? {5%}
  - (b) In a certain binary-star system, each star has the same mass of our Sun, and they revolve about their center of mass. The distance between them is the same as the distance between earth and the Sun. What is their period of revolution in years? {5%} (The mass of the Sun is  $1.99 \times 10^{30}$  kg, the distance between the earth and the Sun is  $1.5 \times 10^{11}$  m)
6. Two large parallel conducting plates carry equal and opposite charges and are separated by a distance of 5 cm. If an  $9\text{-}\mu\text{C}$  point charge placed between the plates experiences a force of  $(2.7 \times 10^{-2} \text{ N}) \hat{i}$ .
  - (a) The potential difference between the plates is \_\_\_\_\_ {5%}
  - (b) The electrical energy stored between the plates is \_\_\_\_\_, assuming the  $9\text{-}\mu\text{C}$  point charge is not there between the plates. {5%}

見背面

7. A metal rod slides at a constant 40 cm/s over frictionless rails separated by 25 cm, as shown in *Figure 1*. A 0.30 T uniform magnetic field is directed out of the page. Assume that the resistance of the rod is  $3.0\ \Omega$  and that the rails have negligible resistance.

- (a) The current flowing in the rails and the direction of the current are \_\_\_\_\_. {5%}
- (b) The mechanical power needed to keep the rod moving at constant velocity is \_\_\_\_\_. {5%}

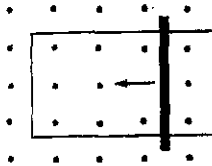


Figure 1: A metal rod slides over frictionless rails in a uniform  $\vec{B}$  field.

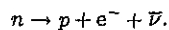
8. A radio station transmits a 10-kW signal at frequency of 100 MHz. For simplicity, assume that it radiates at a point source. At a distance of 1 km from the (point source) antenna,

- (a) the amplitudes of the electric and magnetic field strengths are \_\_\_\_\_. {5%}
- (b) the energy incident normally on a square plate of side 10 cm in 5 min is \_\_\_\_\_. {5%}

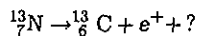
9. Two trains (*A* and *B*), each of proper length 1 km, run on parallel tracks. Train *A* has a velocity of  $0.6c$  while train *B* has a velocity of  $0.8c$  relative to the ground. How long does it take the faster train to fully pass the slower one (from the time when the front of *B* coincides with the rear of *A* to the time when the rear of *B* coincides with the front of *A*)? The answer is

- (a) \_\_\_\_\_ according to observers in the ground frame; {5%}
- (b) \_\_\_\_\_ according to observers in the frame of the slower train. {5%}

10. In  $\beta^-$  decay a neutron in a nucleus is transformed into a proton, an electron, and an antineutrino:



- (a) The physical quantity not conserved in  $\beta^-$  decay is \_\_\_\_\_. {5%}
- (b) The particle denoted by the question mark in the reaction



is \_\_\_\_\_. {5%}

Note that the superscript and subscript in  ${}^{13}_6\text{C}$ , for instance, are respectively the mass number *A* and atomic number *Z* of the carbon nucleus.