

Midterm I for phy231, Wednesday October 4, 2000

Constants:  $g=9.81 \text{ m/s}^2$ ,  $1 \text{ km} = 1000 \text{ m}$

1) A soccer ball is kicked and travels with a constant velocity of 79.2 km/hr. How long does it take to travel 11 m?

- A) 0.10 s
- B) 0.14 s
- C) 0.30 s
- D) 0.40 s
- E) 0.50 s

Answer:  $v = 22 \text{ m/s}$ ,  $t = \frac{x}{v} = 11/22 = 0.5 \text{ s}$ .

2) A ball is thrown up with an initial velocity of 28 m/s. What is its velocity after 4 s?

- A) 7 m/s, up
- B) 7 m/s, down
- C) 11.2 m/s, up
- D) 11.2 m/s, down
- E) 39.2 m/s, down

Answer:  $v = v_o + at$ ,  $a = -g = -9.81 \text{ m/s}^2$ ,  $v = -11.2 \text{ m/s}$ .

3) Three vectors of equal magnitude of 20 cm make angles of  $+90^\circ$ ,  $-90^\circ$ , and  $0^\circ$  with respect to the  $x$  axis. What is the length of the sum of these three vectors?

- A) 0 cm
- B) 10 cm
- C) 20 cm
- D) 40 cm
- E) 60 cm

Answer: The addition of the vectors at  $90^\circ$  and  $-90^\circ$  gives zero. So the total is just the third vector at  $0^\circ$  which has a length of 20 cm.

4) A baseball after being struck with a bat is traveling in the air to the outfield. Which statement is False? (Neglect air resistance.)

- A) The acceleration is the same during the entire flight.
- B) The vertical speed is zero at the highest point of motion.
- C) The speed is least at the highest point of motion.
- D) As the ball is ascending, its speed is decreasing.
- E) As the ball is descending, its horizontal speed increases.

Answer: (E) – The horizontal speed is the same for the entire flight.

5) A student playing darts aim his dart directly at a target (on the same level) 3 m away. If the dart is released with a speed of 30 m/s, by how much will it miss the target?

- A) 0.049 m
- B) 0.10 m
- C) 0.20 m
- D) 0.41 m
- E) 0.51 m

Answer:  $x = vt = 0.1$  s,  $y = \frac{1}{2}at^2 = -0.049$  with  $a=-g$ .

6) A block of mass 20 kg sliding on a frictionless table is attached to another block of mass 10 kg by a string over a massless pulley as indicated. What is the acceleration of the bigger mass (in  $\text{m/s}^2$ )?

- A) 9.81
- B) 6.54
- C) 3.27
- D) 0.981
- E) 0

Answer: Newton's second law for the hanging mass  $m_1$  is  $m_1g - T = m_1a$ , Newton's second law for the mass on the table  $m_2$  is  $T = m_2a$ , solving for  $a$  gives  $a = gm_1/(m_1 + m_2) = 3.27 \text{ m/s}^2$ .

7) Tarzan finds himself stuck in the jungle from two vines as indicated in the adjoining sketch. If his mass is 60 kg and the tension  $T$  is 600 N. What is the angle  $\theta$  in degrees?

- A) 2.9
- B) 5.7
- C) 29.3
- D) 45.0
- E) 78.5

Answer: The component of the tension in the upward direction in each rope is  $T' = T\sin\theta$ . The sum for the two ropes  $2T'$  must be equal to the weight force  $mg$ . This means  $\sin\theta = mg/(2T) = 0.49$ , and  $\theta=29.3^\circ$ .

8) A 180 N force accelerates a cart from 10 m/s to 20 m/s in 5 seconds. What is the mass of the cart?

- A) 90 kg
- B) 180 kg
- C) 270 kg
- D) 360 kg
- E) 540 kg

Answer:  $v = v_o + at$ , to find  $a = (v - v_o)/t = 2 \text{ m/s}^2$ .  $F = ma$ , to find  $m = F/a = 90 \text{ kg}$ .

9) What coefficient of kinetic friction is required to stop an object sliding on a flat surface with a speed of 10 m/s over a distance of 10 m?

- A) 0.35
- B) 0.51
- C) 0.71
- D) 0.89
- E) 1.96

Answer:  $v^2 = v_o^2 + 2ax$ , with  $v=0$  to find  $a=-v_o^2/(2x) = -5 \text{ m/s}^2$ . The net force acting in the direction of motion is due to friction,  $f_k = -\mu_k mg$ . Newton's second law is  $f_k = ma$ , to find  $\mu_k = -a/g = 0.51$ .

10) A block of mass  $m$  slides on a frictionless inclined plane which makes an angle  $\theta$  with the horizontal plane. Which statement is False?

- A) The component of the gravity force parallel to the plane is  $mg \sin\theta$ .
- B) The component of the gravity force normal to the plane is  $mg \cos\theta$ .
- C) The reaction force of the plane is  $mg \cos\theta$ .
- D) The net force acting on the block is zero.
- E) The acceleration of the block depends on the angle  $\theta$ .

Answer: (D) The net force acting is  $mg\sin\theta$ .

11) A roller coaster with mass 1000 kg starts at the top of a hill which is 100 m high. Use energy conservation to find the velocity at the bottom.

- A) 0 m/s
- B) 31.3 m/s
- C) 44.3 m/s
- D) 99.0 m/s
- E) 140.0 m/s

Answer: Energy conservation gives  $mgh = \frac{1}{2}mv^2$ ,  $v = \sqrt{(2gh)} = 44.3$  m/s.

12) A car with mass 1500 kg starts from rest and accelerates with an average power output of 10,000 W. Neglecting air resistance, what is the speed of the car after 20 s?

- A) 2.6 m/s
- B) 3.6 m/s
- C) 5.7 m/s
- D) 11.5 m/s
- E) 16.3 m/s

Answer: The total work input is  $W = Pt$  and by energy conservation this is equal to the final kinetic energy  $W = \frac{1}{2}mv^2$ . Thus  $v = \sqrt{(2Pt/m)} = 16.3$  m/s.

13) A person in a swing starts out from rest at a height of 3.0 meters above the ground. What is the speed at the bottom of the arc which is 0.5 meters above the ground?

- A) 7.0 m/s
- B) 7.7 m/s
- C) 8.3 m/s
- D) 9.0 m/s
- E) 9.5 m/s

Answer: The initial potential energy is  $PE_1 = mgh_1$ , and the initial kinetic energy ( $KE_1$ ) is zero. The final potential energy is  $PE_2 = mgh_2$ , and the final kinetic energy is  $KE_2 = \frac{1}{2}mv^2$ . The sum  $KE+PE$  is constant. Solving for  $v$  gives  $v = \sqrt{(2g\Delta h)}$ , where  $\Delta h = h_1 - h_2 = 2.5$  m. Thus  $v=7.0$  m/s.

14) A machine requires a power input of 1000 W. After running for 20 s the useful energy output is 15,000 J. What is the efficiency?

- A) 25%
- B) 50%
- C) 75%
- D) 100%
- E) 133%

Answer:  $e = \text{efficiency} = (\text{useful work})/(\text{total work input})$ . Work input is  $W = Pt = 20,000$  J, so  $e = (15,000)/(20,000) = 75\%$ .

15) A baseball with a mass of 0.20 kg is hit with an initial velocity of 10.0 m/s. Before it is caught it loses 5.0 J of energy due to air resistance. What is the velocity when it is caught? (Assume that it is caught at the same height that it is hit.)

- A) 7.1 m/s
- B) 10.0 m/s
- C) 15.0 m/s
- D) 17.3 m/s
- E) 20.0 m/s

Answer: Total initial energy is  $KE_i = \frac{1}{2}mv_i^2 = 10$  J. The total final energy is  $KE_f + Q = 10$  J with  $Q = 5$  J. Thus,  $KE_f = \frac{1}{2}mv_f^2 = 5$  J,  $v_f = 7.1$  m/s.