Practice Exam 2

Multiple Choice
Identify the choice that best completes the statement or answers the question.

1. A roller-coaster car has a mass of 500.0 kg when fully loaded with passengers. At the bottom of a circular dip of radius 40.0 m (as shown in the figure) the car has a speed of 16 m/s. What is the magnitude of the force of the track on the car at the bottom of the dip?

   - a. 3.2 kN
   - b. 8.1 kN
   - c. 4.9 kN
   - d. 1.7 kN
   - e. 5.3 kN

→ b 8.1 kN

There be a centripetal acceleration caused by a normal force of the car pressing against the track in addition to a normal force from the car pressing against the track due to gravity.

F = mv^2/r + mg = 500.0*16.0^2/40.0 + 500.0*9.8 = 8100 N = 8.1 kN
2. A 0.30-kg mass attached to the end of a string swings in a vertical circle ($R = 1.6$ m), as shown. At an instant when $\theta = 50^\circ$, the tension in the string is 8.0 N. What is the magnitude of the resultant force on the mass at this instant?

The only forces on the mass are the tension and gravity. However, if the mass is moving in a circle then those must add to give and a tangential acceleration.

- $T = 8.0$ N centripetally inward toward the center of the circle.
- $F_{\text{ge}} = mg\cos(\theta) = 0.30 \times 9.8 \times \cos(50) = 1.8898$ N centripetally outward
- Total $F_{\text{C}} = 8.0 - 1.8898 = 6.1102$ N
- $F_{\text{T}} = mgsin(\theta) = 0.30 \times 9.8 \times \sin(50) = 2.2522$ N tangentially counterclockwise around the circle
- Total force $F = \sqrt{(6.1102)^2 + (2.2522)^2} = 6.5121$ N = 6.5 N

\[ \Rightarrow \text{c 6.5 N} \]

3. A race car traveling at 100 m/s enters an unbanked turn of 400 m radius. The coefficient of (static) friction between the tires and the track is 1.1. The track has both an inner and an outer wall. Which statement is correct?

- a. The race car will crash into the outer wall.
- b. The race car will crash into the inner wall.
- c. The car will stay in the center of the track.
- d. The car will stay in the center of the track if the driver speeds up.
- e. The car would stay in the center of the track if the radius were reduced to 200 m.

\[ \Rightarrow \text{a The race car will crash into the outer wall} \]

The centripetal force has to be provided by the friction. Comparing them

\[
F_{\text{C}} = \frac{mv^2}{r} : F_{\text{T}} = \mu mg
\]

\[
\frac{v^2}{r} : \mu g = \frac{100^2}{400} : 1.1 \times 9.8
\]

\[
25 : 10.78
\]

Friction does not provide enough force to keep the car on the race track turn. The car will crash into the out wall.
Considering the other answers
b incorrect
c would be true if the force of friction where possibly greater than the necessary centripetal force.
d. makes the situation worse requiring even greater friction
e. makes the situation worse requiring even greater friction

4. A hornet circles around a pop can at increasing speed while flying in a path with a 12-cm diameter. We can conclude that the hornet's wings must push on the air with force components that are
   a. straight down.
   b. down and inwards.
   c. down and outwards.
   d. down and backwards.
   e. down, backwards and outwards.

→ c down, backwards and outwards
Down to push against the air so it reacts with a normal force pushing the hornet up to resist gravity.
Backwards to push against the air so it reacts with a normal force pushing forwards so it accelerates
Outwards to push against the air so it reacts with a normal force providing the centripetal force

5. A boy on board a cruise ship drops a 30.0 gm marble into the ocean. If the resistive force proportionality constant is 0.500 kg/s, what is the terminal speed of the marble in m/s?
   a. 0.147
   b. 0.294
   c. 0.588
   d. 1.18
   e. 2.35

→ c 0.588
Using \( \sum F_y = ma = 0 = mg - bv \)
\[ v = \frac{mg}{b} = \frac{0.030 \times 9.8}{0.500} = 0.588 \text{ m/s} \]

6. How much work is done by a person lifting a 2.0-kg object from the bottom of a well at a constant speed of 2.0 m/s for 5.0 s?
   a. 0.22 kJ
   b. 0.20 kJ
   c. 0.24 kJ
   d. 0.27 kJ
   e. 0.31 kJ

→ b 0.20 kJ
To lift at constant speed the person must lift with a force equal in magnitude to the gravitational force. That force and direction of movement are the same so the work is positive
\[ d = v \times t = 2.0 \times 5.0 = 10 \]
\[ W = Fd = mgd = 2.0 \times 9.8 \times 10 = 196 \text{ J} = 0.20 \text{ kJ} \]
7. A 2.0-kg particle has an initial velocity of $5i - 4j$ m/s. Some time later, its velocity is $7i - 3j$ m/s. How much work was done by the resultant force during this time interval, assuming no energy is lost in the process?
   a. 17 J
   b. 49 J
   c. 19 J
   d. 53 J
   e. 27 J

$\Rightarrow$ a 17 J

The work done by the force results in change in kinetic energy. Using the work energy theorem

\[ W = \Delta K = K_f - K_i = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = \frac{1}{2} \cdot 2.0 \cdot (7^2 + 3^2) - \frac{1}{2} \cdot 2.0 \cdot (5^2 + 4^2) = 17 \text{ J} \]

8. The horizontal surface on which the block slides is frictionless. The speed of the block before it touches the spring is 6.0 m/s. How fast is the block moving at the instant the spring has been compressed 15 cm? $k = 2.0 \text{ kN/m}$

$\Rightarrow$ a 3.7 m/s

The spring is a conservative force

\[ W_{\text{cons}} = \Delta K = K_f - K_i = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = - (U_f - U_i) = - \left( \frac{1}{2} k x_f^2 - \frac{1}{2} k x_i^2 \right) \]
\[ \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = - \left( \frac{1}{2} k x_f^2 - \frac{1}{2} k x_i^2 \right) \]
\[ \frac{1}{2} \cdot 2.0 \cdot v_f^2 - \frac{1}{2} \cdot 2.0 \cdot 6.0^2 = - \left( \frac{1}{2} \cdot 2000 \cdot 0.15^2 \right) \]
\[ v_f^2 - 6.0^2 = -(1000 \cdot 0.15^2) \]
\[ v_f = 3.7 \text{ m/s} \]

9. When a ball rises vertically to a height $h$ and returns to its original point of projection, the work done by the gravitational force is
   a. 0.
   b. $-mgh$.
   c. $+mgh$.
   d. $-2mgh$.
   e. $+2mgh$.

$\Rightarrow$ a 0

For a conservative force the work depends only on the end points which are the same so the work is zero. Alternatively for a conservative force the work is equal to negative the change in potential energy which is zero.
10. After a skydiver reaches terminal velocity, 
   a. the force of gravity no longer performs work on the skydiver. 
   b. work performed by the force of gravity is converted into gravitational potential energy. 
   c. gravitational potential energy is no longer available to the system of the skydiver plus the Earth. 
   d. gravitational potential energy is converted into thermal energy. 
   e. thermal energy is converted into gravitational potential energy. 

   ➔ d gravitational potential energy is converted into thermal energy. 
   Gravity still doing positive work on the skydiver. The drag force is doing equal in magnitude but negative work. The total work is zero so there is no change in kinetic energy. Considering total conservation of energy the potential energy that is lost because heat.

Considering the other answers
   a. The skydiver is still moving down so gravity does positive work 
   b. The skydiver is losing potential energy 
   c. You could push the skydiver up again to restore the gravitational potential energy 
   e. The skydiver is losing potential energy

11. A 0.04-kg ball is thrown from the top of a 30-m tall building (point A) at an unknown angle above the horizontal. As shown in the figure, the ball attains a maximum height of 10 m above the top of the building before striking the ground at point B. If air resistance is negligible, what is the value of the kinetic energy of the ball at B minus the kinetic energy of the ball at A ($K_B - K_A$)?

   ➔ a 12 J 
   The only force in the system is gravity which is conservative so we can use conservation of energy, specifically mechanical energy is conserved in system with only conservative forces. 

   Between A and B the gravitational potential energy due to a higher of 30m is converted to kinetic energy increasing the kinetic energy at B 

   $mgh = 0.04 \times 9.8 \times 30 = 11.76 = 12 \text{ J}$
12. The block shown is released from rest when the spring is stretched a distance $d$. If $k = 50 \text{ N/m}$, $m = 0.50 \text{ kg}$, $d = 10 \text{ cm}$, and the coefficient of kinetic friction between the block and the horizontal surface is equal to 0.25, determine the speed of the block when it first passes through the position for which the spring is unstretched.

- a. $92 \text{ cm/s}$
- b. $61 \text{ cm/s}$
- c. $71 \text{ cm/s}$
- d. $82 \text{ cm/s}$
- e. $53 \text{ cm/s}$

Using the Work energy theorem work is done by the spring and the friction force

$$W = \Delta K = K_f - K_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

The spring does positive work and as a conservative force that work is equal in magnitude to the change in potential energy. Friction does negative work

$$-\left(\frac{1}{2}kx_f^2 - \frac{1}{2}kx_i^2\right) - \mu_kmgd = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$-\left(\frac{1}{2} \times 50 \times 0.1^2\right) - 0.25 \times 0.50 \times 9.8 \times 0.10 = \frac{1}{2} \times 0.50v^2$$

$$(25 \times 0.1^2) - 0.25 \times 0.50 \times 9.8 \times 0.10 = 0.25v^2$$

$$v = 0.71 \text{ m} = 71 \text{ cm/s}$$

13. Objects A and B, of mass $M$ and 2$M$ respectively, are each pushed a distance $d$ straight up an inclined plane by a force $F$ parallel to the plane. The coefficient of kinetic friction between each mass and the plane has the same value $\mu_k$. At the highest point,

- a. $K_A > K_B$
- b. $K_A = K_B$
- c. $K_A < K_B$
- d. The work done by $F$ on A is greater than the work done by $F$ on B.
- e. The work done by $F$ on A is less than the work done by $F$ on B.

Using the work energy theory

$$\sum W = Fd - F_f d - F_g h = \Delta K = K_f - K_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$\sum W = Fd - mg\cos(\theta)d - mg\sin(\theta) = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

Larger mass is going to mean less total work and a lower kinetic energy
14. Two blocks with masses 2.0 kg and 3.0 kg are placed on a horizontal frictionless surface. A light spring is placed in a horizontal position between the blocks. The blocks are pushed together, compressing the spring, and then released from rest. After contact with the spring ends, the 3.0-kg mass has a speed of 2.0 m/s. How much potential energy was stored in the spring when the blocks were released?

a. 15 J  
b. 3.0 J  
c. 6.0 J  
d. 12 J  
e. 9.0 J

→ a 15 J

If the 3.0 kg block has a 2.0 m/s the 2.0 kg block must have a 3.0 m/s to have equal magnitude but opposite direction momentum.

\[ K = \frac{1}{2} \times 3 \times 2^2 + \frac{1}{2} \times 2 \times 3^2 = 15 \text{ J} \]

Since the spring causes a conservative force 15 J or potential energy was converted to kinetic energy in this system.

15. The value of the momentum of a system is the same at a later time as at an earlier time if there are no

a. collisions between particles within the system.

b. inelastic collisions between particles within the system.

c. changes of momentum of individual particles within the system.

d. internal forces acting between particles within the system.

e. external forces acting on particles of the system.

→ c external forces acting on particles of the system.

Considering the other answers

a momentum is conserved in collisions

b even inelastic collisions – though energy can be lost in inelastic collisions

c momentum is conserved so a change in momentum would results in an opposite change in the other participle

d internal forces come in action/reaction pairs which would lead to equal magnitude but opposite direction changes in the momentum of the particles conserving the total momentum of the system. We used this fact to prove conservation of momentum.

16. A 2.0-kg object moving 3.0 m/s strikes a 1.0-kg object initially at rest. Immediately after the collision, the 2.0-kg object has a velocity of 1.5 m/s directed 30° from its initial direction of motion. What is the \( y \) component of the velocity of the 1.0-kg object just after the collision?

a. \(-3.7 \text{ m/s}\)

b. \(-3.4 \text{ m/s}\)

c. \(-1.5 \text{ m/s}\)

d. \(-2.4 \text{ m/s}\)

e. \(-4.1 \text{ m/s}\)

→ c \(-1/5 \text{ m/s}\)

Note that we do not state that the collision is elastic so we can’t assume the other object is 90 degree from the 1st object.

\[ \text{pxi} = 2.0 \times 3.0 = 6.0 \]

\[ \text{pyi} = 0 \]

\[ \text{pyf} = 0 = \text{pyf1} + \text{pyf2} = 2.0 \times 1.5 \times \sin(30°) + \text{pyf2} \]

\[ \text{pyf2} = -1.5 \text{ m/s} \]
17. A 3.0-kg mass sliding on a frictionless surface explodes into three 1.0-kg masses. After the explosion the velocities of the three masses are: (1) 9.0 m/s, north; (2) 4.0 m/s, 30° south of west; and (3) 4.0 m/s, 30° south of east. What was the magnitude of the original velocity of the 3.0-kg mass?
   a. 1.7 m/s
   b. 1.0 m/s
   c. 1.3 m/s
   d. 2.0 m/s
   e. 2.8 m/s

   → a 1.7 m/s

   call north positive y and east positive x
   \( p_i = p_f \)
   \( p_{xi} = p_{xf} = 0 \) the components in the x direction are equal and opposite each other
   \( p_{yi} = p_{yf} = 1.0*9.0 - 1.0*4.0*\sin(30) - 1.0*4.0*\sin(30) = 5 = 3.0*v, v = 1.7m/s \)

18. At the instant a 2.0-kg particle has a velocity of 4.0 m/s in the positive x direction, a 3.0-kg particle has a velocity of 5.0 m/s in the positive y direction. What is the speed of the center of mass of the two-particle system?
   a. 3.8 m/s
   b. 3.4 m/s
   c. 5.0 m/s
   d. 4.4 m/s
   e. 4.6 m/s

   → b 3.4 m/s
   \( v_x = (2*4+3*0)/5 = 1.6 \)
   \( v_y = (2*0+3*5)/5 = 3.0 \)
   \( v = \sqrt{1.6*1.6 + 3.0*3.0} = 3.4 \) m/s

19. Two bodies with masses \( m_1 \) and \( m_2 \) are both moving east with velocities of magnitudes \( v_1 \) and \( v_2 \), where \( v_1 \) is less than \( v_2 \). The magnitude of the velocity of the center of mass of this system of two bodies is
   a. less than \( v_1 \).
   b. equal to \( v_1 \).
   c. equal to the average of \( v_1 \) and \( v_2 \).
   d. greater than \( v_1 \) and less than \( v_2 \).
   e. greater than \( v_2 \).

   → d greater than \( v_1 \) and less than \( v_2 \).
   Note: could be c, but only in the case where the masses are the same

20. A 6.0-kg object, initially at rest in free space, "explodes" into three segments of equal mass. Two of these segments are observed to be moving with equal speeds of 20 m/s with an angle of 60° between their directions of motion. How much kinetic energy is released in this explosion?
Consider the two objects as moving together along positive x with one 30 degrees above the axis and one 30 degrees below. Their y components cancel out. Their combined momentum is:

\[ p_x = 2 \times 2.0 \times 20 \cos(30) = 69.282 \]

The third object moves in the negative x direction with that momentum and a velocity of 34.641.

The total kinetic energy is:

\[ 0.5 \times 2.0 \times 20^2 + 0.5 \times 2.0 \times 20^2 + 0.5 \times 2.0 \times 34.641^2 = 2000 \text{ J} = 2.0 \text{ kJ} \]
Practice Exam 2
Answer Section

MULTIPLE CHOICE

1. ANS: B
2. ANS: C
3. ANS: A
4. ANS: E
5. ANS: C
6. ANS: B
7. ANS: A
8. ANS: A
9. ANS: A
10. ANS: D
11. ANS: A
12. ANS: C
13. ANS: A
14. ANS: A
15. ANS: E
16. ANS: C
17. ANS: A
18. ANS: B
19. ANS: D
20. ANS: C