

# Physics 11

## Dynamics Unit Retest 2 Solutions

1. a. ☐ b. ☒
2. a. ☒ b. ☐
3. a. ☐ b. ☒
4. a. ☒ b. ☐ c. ☐ d. ☒
5. a. ☐ b. ☐ c. ☒ d. ☐
6. a. ☐ b. ☐ c. ☒ d. ☐
7. a. ☐ b. ☐ c. ☐ d. ☒
8. a. ☐ b. ☒ c. ☐ d. ☐
9. a. ☒ b. ☐ c. ☐ d. ☐
10. a. ☐ b. ☐ c. ☒ d. ☐
11. a. ☐ b. ☒ c. ☐ d. ☐
12. a. ☐ b. ☐ c. ☒ d. ☐
13. a. ☒ b. ☐ c. ☐ d. ☐
14. a. ☐ b. ☒ c. ☐ d. ☐
15. a. ☐ b. ☐ c. ☒ d. ☐
16. a. ☐ b. ☐ c. ☒ d. ☐
17. a. ☐ b. ☐ c. ☒ d. ☐
18. a. ☐ b. ☐ c. ☒ d. ☐
19. a. ☒ b. ☐ c. ☐ d. ☐
20. a. ☐ b. ☐ c. ☒ d. ☐

**1. Problem**

True or false? If an object is in equilibrium (i.e. all the forces on it are balanced), then the object must be at rest.

- a. True
- b. False

**Solution**

False. An object in equilibrium must have zero acceleration, but its velocity is not necessarily zero.

**2. Problem**

True or false? An object weighs less on the moon than it does on earth.

- a. True
- b. False

**Solution**

True. Weight is the force of gravity. The gravitational field strength on the moon is less than on earth, so objects weigh less on the moon.

**3. Problem**

True or false? A ball is thrown upwards and rightwards. While it is in the air, the net force on the ball is directed upwards and rightwards.

- a. True
- b. False

**Solution**

False. The only force on the ball while it is in the air is the force of gravity, which points downward (assuming no air resistance).

**4. Problem**

A box that weighs 100 N rests on a digital scale on the floor of an elevator. When would the scale measure a value greater than 100 N? *Select all that apply.*

- a. moving upward with increasing speed.
- b. moving upward with decreasing speed.
- c. moving downward with increasing speed.
- d. moving downward with decreasing speed.

**Solution**

The force of gravity is always downward while the normal force provided by the scale always points upward. The scale measures the normal force on it. If the acceleration is upward, then the normal force must be greater (so the scale would measure a greater weight). If the acceleration is downward, then the normal force must be less (so the scale would measure a smaller weight).

The acceleration is downward when the elevator is moving down with increasing speed and when the elevator is moving up with decreasing speed.

**5. Problem**

In a rugby game, Bob (mass = 98 kg) tackles Joe (mass = 76 kg) and knocks Joe to the ground. During the collision, who applied the greater force on whom?

- a. Bob applied a greater force on Joe (than Joe did on him).
- b. Joe applied a greater force on Bob (than Bob did on him).
- c. Bob and Joe applied the same magnitude force on each other.
- d. It depends on the relative speeds of Bob and Joe.

**Solution**

According to Newton's Third Law of Motion, the force of Bob on Joe is equal (but opposite) the force of Joe on Bob.

**6. Problem**

Why is a greater force needed to start moving a heavy box from rest than to keep pushing it with constant velocity? In the choices below,  $\mu_k$  is the coefficient of kinetic friction and  $\mu_s$  is the coefficient of static friction.

- a.  $\mu_s < \mu_k$
- b. The normal force is greater when the box is at rest.
- c.  $\mu_k < \mu_s$
- d. The inertia of the box is greater when it is at rest.

**Solution**

$\mu_k < \mu_s$ . The coefficient of kinetic friction is less than the coefficient of static friction.

**7. Problem**

A physics textbook of mass  $m$  is at rest on a flat table. Earth's gravity applies a downward force  $mg$  on the book, which we will call the action force. What is the reaction force?

- a. The table pushing down on the floor with force  $mg$ .
- b. The book pushing down on the table with force  $mg$ .
- c. The table pushing up on the book with force  $mg$ .
- d. The book pulling upward on the Earth with force  $mg$ .

**Solution**

Action-reaction force pairs are always between the same two objects. The reaction force to the Earth pulling down on the book is the book pulling upward on the Earth with force.

**8. Problem**

A box, of mass  $M$ , is suspended by a string from the ceiling inside an elevator. The elevator is traveling downward with a constant speed. The tension in the string is

- a. less than  $Mg$ .
- b. equal to  $Mg$ .
- c. greater than  $Mg$ .
- d. impossible to determine without knowing the speed.

**Solution**

The elevator is moving with constant velocity so the acceleration is zero and the net force must also be zero. Therefore, the tension force must balance (equal) the gravitational force,  $Mg$ .

**9. Problem**

You place a 49.13-kg object on a spring scale. If the scale reads 401.4 N, what is the acceleration of gravity at that location?

- a.  $8.17 \text{ m/s}^2$
- b.  $10.57 \text{ m/s}^2$
- c.  $8.19 \text{ m/s}^2$
- d.  $8.41 \text{ m/s}^2$

**Solution**

The acceleration of gravity ( $g$ ) is related to the mass ( $m$ ) and weight ( $W$ ) of objects by the equation  $W = mg$ . Solving for  $g$ , we get

$$g = \frac{W}{m} = \frac{401.4 \text{ N}}{49.13 \text{ kg}} = 8.17 \text{ m/s}^2$$

**10. Problem**

An object of mass 12.0 kg accelerates at  $8.0 \text{ m/s}^2$ . What is the magnitude of the net force on the object?

- a. 58 N
- b. 130 N
- c. 96 N
- d. 110 N

**Solution**

According to Newton's Second Law of Motion

$$F = ma = (12 \text{ kg})(8 \text{ m/s}^2) = 96 \text{ N}$$

**11. Problem**

A box slides down an inclined plane with a constant velocity. The angle of incline is  $40.0^\circ$ . What is the coefficient of kinetic friction between the box and the inclined plane?

- a. 1.245
- b. 0.839
- c. 0.992
- d. 0.435

**Solution**

On an inclined plane, the normal force is equal to the perpendicular component of the force of gravity:

$$F_N = mg \cos \theta$$

For constant velocity, zero acceleration motion, the friction force must be equal to the parallel component of the force of gravity:

$$F_f = \mu_k F_N = \mu_k mg \cos \theta = mg \sin \theta$$

Therefore, the coefficient of kinetic friction,  $\mu_k$ , is:

$$\mu_k = \frac{\sin \theta}{\cos \theta} = \tan \theta = \tan(40^\circ) = 0.839$$

**12. Problem**

As the angle of an inclined plane increases, the parallel force \_\_\_\_\_ and the perpendicular force \_\_\_\_\_.

- a. decreases, decreases
- b. decreases, increases
- c. increases, decreases
- d. increases, increases

**Solution**

The parallel force increases and the perpendicular force decreases.

**13. Problem**

Adam pulls on a box with 14.0 N of force. Bob pulls on the the same box with 11.0 N of force, at a right angle to Adam's force. What is the magnitude of the net force on the box?

- a. 17.8 N
- b. 13.1 N
- c. 11.1 N
- d. 15.2 N

**Solution**

Perpendicular forces are added using the Pythagorean theorem.

$$F_{net} = \sqrt{F_1^2 + F_2^2} = \sqrt{(14\text{N})^2 + (11\text{N})^2} = 17.8\text{ N}$$

**14. Problem**

Xavier pulls on a box with 43.0 N of force at  $0^\circ$ . Yuri pulls on the the same box with 47.0 N of force, at  $90^\circ$ . What is the angle of the net force?

- a.  $51.8^\circ$
- b.  $48.0^\circ$
- c.  $69.8^\circ$
- d.  $79.6^\circ$

**Solution**

The angle can be found using the arctangent.

$$\theta = \tan^{-1}(47/43) = 48^\circ$$

**15. Problem**

Charlie pulls on a box with 35.0 N of force at  $160^\circ$ . Dan pulls on the the same box with 19.0 N of force at  $-161^\circ$ . What is the angle of the net force on the box?

- a.  $179.2^\circ$
- b.  $-177.6^\circ$
- c.  $173.5^\circ$
- d.  $-131.9^\circ$

**Solution**

The sum of the horizontal components is

$$F_{net,x} = (35N) \cos(160^\circ) + (19N) \cos(-161^\circ) = -50.8540947N$$

The sum of the vertical components is

$$F_{net,y} = (35N) \sin(160^\circ) + (19N) \sin(-161^\circ) = 5.7849101N$$

The angle of the net force is

$$\theta = \tan^{-1}(5.7849101 / -50.8540947) = 173.5^\circ$$

#### 16. Problem

Two boxes connected by a light cord are on a frictionless table as shown in the diagram. The masses are  $m_1 = 89 \text{ kg}$  and  $m_2 = 534 \text{ kg}$ . A 770-N force is applied horizontally on the right box. What is the tension in the cord?



- a. 781 N
- b. 594 N
- c. 660 N
- d. 646 N

#### Solution

The acceleration of the system of two boxes is

$$a = \frac{770 \text{ N}}{89 \text{ kg} + 534 \text{ kg}}$$

The tension in the cord is the net force on  $m_2$  and it is equal to  $m_2$  times the acceleration

$$F_{tension} = (534 \text{ kg}) \left( \frac{770 \text{ N}}{89 \text{ kg} + 534 \text{ kg}} \right) = 660 \text{ N}$$

#### 17. Problem

Two forces act on an object. A 14.0-N force acts at  $-102^\circ$ . A 39.0-N force acts at  $-104^\circ$ . What is the angle of their equilibrant?

- a.  $153.7^\circ$
- b.  $-50.7^\circ$
- c.  $76.5^\circ$
- d.  $-156.2^\circ$

#### Solution

The sum of the horizontal components is

$$F_{net,x} = (14N) \cos(-102^\circ) + (39N) \cos(-104^\circ) = -12.3457176N$$

The sum of the vertical components is

$$F_{net,y} = (14N) \sin(-102^\circ) + (39N) \sin(-104^\circ) = -51.5355997N$$

The angle of the net force is

$$\theta_{net} = \tan^{-1}(-51.5355997 / -12.3457176) = -103.5^\circ$$

The direction of the equilibrant is opposite that of the net force so we add or subtract  $180^\circ$ .

$$\theta_{eq} = 76.5^\circ$$

Or

$$\theta_{eq} = -283.5^\circ$$

**18. Problem**

A box of mass 49 kg slides down a frictionless inclined plane. The angle of incline is  $51^\circ$  from the horizontal. What is the acceleration of the box?

- a.  $9.2 \text{ m/s}^2$
- b.  $8.4 \text{ m/s}^2$
- c.  $7.6 \text{ m/s}^2$
- d.  $5.5 \text{ m/s}^2$

**Solution**

The acceleration is

$$a = g \sin \theta = (9.8 \text{ m/s}^2) \sin(51^\circ) = 7.6 \text{ m/s}^2$$

**19. Problem**

A box of mass 18 kg slides down an inclined plane with friction. The angle of incline is  $33^\circ$  and  $\mu_k = 0.19$ . What is the acceleration of the box?

- a.  $3.8 \text{ m/s}^2$
- b.  $1.3 \text{ m/s}^2$
- c.  $0.1 \text{ m/s}^2$
- d.  $2.3 \text{ m/s}^2$

**Solution**

The acceleration is

$$a = g(\sin \theta - \mu \cos \theta) = 3.8 \text{ m/s}^2$$

**20. Problem**

An 7-kg box slides down a  $14^\circ$  inclined plane with constant acceleration. The box starts from rest at the top. At the bottom, its velocity reaches 1.76 m/s. The length of the incline is 4.52 m. What is the coefficient of kinetic friction between the box and the plane?

- a. 0.154
- b. 0.098
- c. 0.213
- d. 0.015

**Solution**

The acceleration of the box can be calculated using the constant acceleration formula  $v_f^2 = v_i^2 + 2ad$ . Since  $v_i = 0$ , we the acceleration is

$$a = \frac{v_f^2}{2d} = \frac{(1.76 \text{ m/s})^2}{2(4.52 \text{ m})} = 0.3426549 \text{ m/s}^2$$

The acceleration down an inclined plane with friction is

$$a = g \sin \theta - \mu g \cos \theta$$

Solving for  $\mu$

$$\mu = \tan \theta - \frac{a}{g \cos \theta} = \tan(14^\circ) - \frac{(0.3426549 \text{ m/s}^2)}{(9.80 \text{ m/s}^2) \cos(14^\circ)}$$

$$\mu = 0.213$$