Physics 11
Dynamics Unit Retest Solutions

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

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? If an object is moving to the left, then the net force on it must point to the left.

   a. True
   b. False

   Solution
   False. The net force is the direction of acceleration, not the direction of motion (velocity).

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**
   A person of mass 97 kg pushes on a wall with 76 N of force. What is the magnitude of the force that the wall exerts on the person?

   a. 740 N
   b. 7.8 N
   c. 76 N
   d. 950 N

   Solution
   According to Newton's Third Law of Motion, the wall exerts an equal and opposite force on the person (the person's mass has nothing to do with the answer).

6. **Problem**
   A rocket moves through outer space with a constant velocity of 9.8 m/s toward the Andromeda galaxy. What is the net force acting on the rocket?

   a. A force equal to the gravity acting on it.
   b. Cannot be determined without more information.
   c. A force equal to its weight on Earth, mg.
   d. The net force is zero.

   Solution
   Since the rocket is moving with constant velocity, its acceleration is zero and the net force acting on the rocket must also be zero.

7. **Problem**
   An apple is falling straight down toward the ground. Take the weight of the apple to be the action force. What is the reaction force?

   a. The air resistance pushing up on the apple.
   b. The force of impact when the object hits the ground.
   c. The apple's gravity pulling upward on the Earth.
   d. There is no reaction force because the apple is not touching anything.

   Solution
   The apple applies an equal and opposite gravitational pull on the Earth.

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 28.06-kg object on a spring scale. If the scale reads 373.2 N, what is the acceleration of gravity at that location?

   a. $13.3\,\mathrm{m/s^2}$
   b. $17.24\,\mathrm{m/s^2}$
   c. $10.3\,\mathrm{m/s^2}$
   d. $7.17\,\mathrm{m/s^2}$

   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

   $$g = \frac{W}{m} = \frac{373.2\,\mathrm{N}}{28.06\,\mathrm{kg}} = 13.30\,\mathrm{m/s^2}$$

10. **Problem**
    An object of mass 11.0 kg accelerates at 1.0 m/s^2. What is the magnitude of the net force on the object?

    a. 7.3 N
    b. 11 N
    c. 12 N
    d. 15 N

    Solution
    According to Newton's Second Law of Motion

    $$F = ma = (11\,\mathrm{kg})(1\,\mathrm{m/s^2}) = 11\,\mathrm{N}$$

11. **Problem**
    An box is at rest on an inclined plane. The angle of incline is increased slowly. When the angle reaches $10.0°$, the box begins to slide. What is the coefficient of static friction between the box and the inclined plane?

    a. 0.208
    b. 0.138
    c. 0.176
    d. 0.095

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

    $$F_N = mg\cos\theta$$

    The friction force when the object starts to slide, the maximum static friction force is reached and it must be equal to the parallel component of the force of gravity:

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

Therefore, the coefficient of static friction, μ_s, is:

$$\mu_s = \frac{\sin\theta}{\cos\theta} = \tan\theta = \tan(10^\circ) = 0.176$$

12. **Problem**
What force is needed to keep a 22-kg box moving at a constant velocity across a warehouse floor if the coefficient of kinetic friction between the box and the floor is 0.61?

    a. 130 N
    b. 110 N
    c. 13 N
    d. 45 N

    Solution
The applied force needed for constant velocity (zero acceleration) is one that balances the friction force.

$$F_f = \mu_k F_N = \mu m g = (0.61)(22\,\text{kg})(9.8\,\text{N}/\text{kg}) = 130\,\text{N}$$

13. **Problem**
Adam pulls on a box with 12.0 N of force. Bob pulls on the the same box with 7.0 N of force, at a right angle to Adam's force. What is the magnitude of the net force on the box?

    a. 13.9 N
    b. 7.5 N
    c. 10.7 N
    d. 8.9 N

    Solution
Perpendicular forces are added using the Pythagorean theorem.

$$F_{net} = \sqrt{F_1^2 + F_2^2} = \sqrt{(12N)^2 + (7N)^2} = 13.9 \text{ N}$$

14. **Problem**
Xavier pulls on a box with 39.0 N of force at 0°. Yuri pulls on the the same box with 35.0 N of force, at 90°. What is the angle of the net force?

    a. 43.0°
    b. 80.6°
    c. 42.0°
    d. 47.5°

    Solution
The angle can be found using the arctangent.

$$\theta = \tan^{-1}(35/39) = 42^\circ$$

15. **Problem**
Robert pulls on a box with 64.0 N of force at $166°$. Steve pulls on the the same box with 22.0 N of force at $351°$. What is the magnitude of the net force on the box?

a. 63.1 N
b. 45.3 N
c. 56.6 N
d. 42.1 N

Solution
The sum of the horizontal components is

$$F_{net,x} = (64N)\cos(166°) + (22N)\cos(351°) = -40.369783N$$

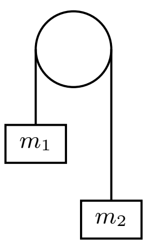
The sum of the vertical components is

$$F_{net,y} = (64N)\sin(166°) + (22N)\sin(351°) = 12.0414431N$$

The magnitude of the net force is

$$F_{net} = \sqrt{(-40.369783N)^2 + (12.0414431N)^2} = 42.1 \text{ N}$$

16. **Problem**
Two masses are attached to a lightweight cord that passes over a frictionless pulley as shown in the diagram. The values of the masses are $m_1 = 46.0$ kg and $m_2 = 90.0$ kg. The hanging masses are free to move. What is the tension in the cord?



a. 513 N
b. 302 N
c. 386 N
d. 597 N

Solution
The acceleration (where m_1 moving downward is positive) is

$$a = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g$$

Newton's Second Law for m_2 is $T - m_2 g = m_2 a$. Rearranging for T gives

$$T = m_2(g + a) = m_2 g \left(1 + \frac{m_1 - m_2}{m_1 + m_2}\right) = \left(\frac{2m_1 m_2}{m_1 + m_2}\right) g$$

The answer is

$$T = 597 \text{ N}$$

17. **Problem**
    Two forces act on an object. A 99.0-N force acts at $-47°$. A 94.0-N force acts at $-135°$. What is the angle of their equilibrant?

    a. $90.4°$
    b. $66.6°$
    c. $-158.0°$
    d. $8.9°$

    Solution
    The sum of the horizontal components is

    $$F_{net,x} = (99N)\cos(-47°) + (94N)\cos(-135°) = 1.0498002N$$

    The sum of the vertical components is

    $$F_{net,y} = (99N)\sin(-47°) + (94N)\sin(-135°) = -138.8720539N$$

    The angle of the net force is

    $$\theta_{net} = \tan^{-1}(-138.8720539/1.0498002) = -89.6°$$

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

    $$\theta_{eq} = 90.4°$$

    Or

    $$\theta_{eq} = -269.6°$$

18. **Problem**
    A box of mass 61 kg slides down a frictionless inclined plane. The angle of incline is $72°$ from the horizontal. What is the acceleration of the box?

    a. $9.3\,\mathrm{m/s^2}$
    b. $10.6\,\mathrm{m/s^2}$
    c. $8.1\,\mathrm{m/s^2}$
    d. $10.7\,\mathrm{m/s^2}$

    Solution
    The acceleration is

    $$a = g\sin\theta = (9.8\,\mathrm{m/s^2})\sin(72°) = 9.3\,\mathrm{m/s^2}$$

19. **Problem**
    A box of mass 98 kg slides down an inclined plane with friction. The angle of incline is $34°$ and $\mu_k = 0.26$. What is the acceleration of the box?

    a. $3.4\,\mathrm{m/s^2}$
    b. $7.2\,\mathrm{m/s^2}$
    c. $0.8\,\mathrm{m/s^2}$
    d. $1.1\,\mathrm{m/s^2}$

    Solution
    The acceleration is

    $$a = g(\sin\theta - \mu\cos\theta) = 3.4\,\mathrm{m/s^2}$$

20. **Problem**
An 8.2-kg box slides down a 15° inclined plane with constant acceleration. The box starts from rest at the top. At the bottom, its velocity reaches 1.74 m/s. The length of the incline is 3.49 m. What is the coefficient of kinetic friction between the box and the plane?

    a. 0.222
    b. 0.260
    c. 0.332
    d. 0.191

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

$$a = \frac{v_f^2}{2d} = \frac{(1.74\,\mathrm{m/s})^2}{2(3.49\,\mathrm{m})} = 0.4337536\,\mathrm{m/s^2}$$

The acceleration down an inclined plane with friction is

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

Solving for μ

$$\mu = \tan\theta - \frac{a}{g\cos\theta} = \tan(15^\circ) - \frac{(0.4337536\,\mathrm{m/s^2})}{(9.80\,\mathrm{m/s^2})\cos(15^\circ)}$$

$$\mu = 0.222$$