Physics 11
Dynamics Unit Retest 2 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 less 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 63 kg pushes on a wall with 94 N of force. What is the magnitude of the force that the wall exerts on the person?

   a. 920 N
   b. 9.6 N
   c. 94 N
   d. 620 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. The net force is zero.
   b. A force equal to its weight on Earth, mg.
   c. A force equal to the gravity acting on it.
   d. Cannot be determined without more information.

   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**
   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 table pushing up on the book with force mg.
   c. The book pushing down on the table 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 76.89-kg object on a spring scale. If the scale reads 1268 N, what is the acceleration of gravity at that location?

   a. $23.21\,\mathrm{m/s^2}$
   b. $17.79\,\mathrm{m/s^2}$
   c. $16.49\,\mathrm{m/s^2}$
   d. $21.72\,\mathrm{m/s^2}$

   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

   $$g = \frac{W}{m} = \frac{1268\,\mathrm{N}}{76.89\,\mathrm{kg}} = 16.49\,\mathrm{m/s^2}$$

10. **Problem**
    An object of mass 19.0 kg accelerates at 5.0 m/s^2. What is the magnitude of the net force on the object?

    a. 95 N
    b. 50 N
    c. 62 N
    d. 73 N

    Solution
    According to Newton's Second Law of Motion

    $$F = ma = (19\,\mathrm{kg})(5\,\mathrm{m/s^2}) = 95\,\mathrm{N}$$

11. **Problem**
    An box is at rest on an inclined plane. The angle of incline is increased slowly. When the angle reaches $49.0°$, the box begins to slide. What is the coefficient of static friction between the box and the inclined plane?

    a. 0.057
    b. 0.617
    c. 1.150
    d. 0.913

    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:

$$\mu_s = \frac{\sin\theta}{\cos\theta} = \tan\theta = \tan(49^\circ) = 1.150$$

12. **Problem**
What force is needed to keep a 17-kg box moving at a constant velocity across a warehouse floor if the coefficient of kinetic friction between the box and the floor is 0.25?

    a. 52 N
    b. 42 N
    c. 18 N
    d. 4.2 N

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

$$F_f = \mu_k F_N = \mu m g = (0.25)(17\,\text{kg})(9.8\,\text{N/kg}) = 42\,\text{N}$$

13. **Problem**
Two forces act on an object. A 14-N force acts at 0° and a 25-N force acts at 90°. What is the magnitude of the equilibrant?

    a. 36.7 N
    b. 17.7 N
    c. 26.7 N
    d. 28.7 N

    Solution
Perpendicular forces are added using the Pythagorean theorem. The equilibrant has the same magnitude as the sum of the two forces.

$$F_{eq} = \sqrt{14N + 25N} = 28.7 \text{ N}$$

14. **Problem**
Carly pulls on a box with 19.0 N of force. Debby pulls on the the same box at a right angle to Carly. How hard must Debby pull to make the resultant force on the box 20.0 N?

    a. 6.2 N
    b. 4.4 N
    c. 7.4 N
    d. 5.4 N

    Solution
Perpendicular forces are related by the Pythagorean theorem.

$$F_{Debby} = \sqrt{F_{net}^2 - F_{Carly}^2} = \sqrt{(20N)^2 - (19N)^2} = 6.24 \text{ N}$$

15. **Problem**
Charlie pulls on a box with 20.0 N of force at $127°$. Dan pulls on the the same box with 46.0 N of force at $-91°$. What is the angle of the net force on the box?

   a. $-113.2°$
   b. $104.5°$
   c. $-10.7°$
   d. $161.2°$

Solution
The sum of the horizontal components is

$$F_{net,x} = (20N)\cos(127°) + (46N)\cos(-91°) = -12.8391112N$$

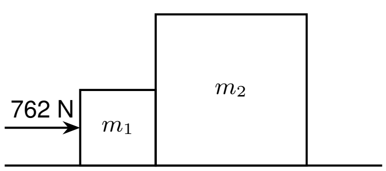
The sum of the vertical components is

$$F_{net,y} = (20N)\sin(127°) + (46N)\sin(-91°) = -30.0202838N$$

The angle of the net force is

$$\theta = \tan^{-1}(-30.0202838/-12.8391112) = -113.2°$$

16. **Problem**
Two boxes are in contact with each other on a frictionless table as shown in the diagram. The masses are $m_1 = 27$ kg and $m_2 = 135$ kg. The first box (m_1)is pushed with a horizontal force of 762 N to the right. What is the net force on the second box (m_2)?



   a. 910 N
   b. 635 N
   c. 365 N
   d. 484 N

Solution
The acceleration of the system of two boxes is

$$a = \frac{762\,\mathrm{N}}{27\,\mathrm{kg} + 135\,\mathrm{kg}}$$

The net force on m_2 is its mass times its acceleration

$$F_{net,2} = (135\,\mathrm{kg})\left(\frac{762\,\mathrm{N}}{27\,\mathrm{kg} + 135\,\mathrm{kg}}\right) = 635\,\mathrm{N}$$

17. **Problem**
    Two forces act on an object. A 18.0-N force acts at $-28°$. A 96.0-N force acts at $-175°$. What is the angle of their equilibrant?

    a. $-56.2°$
    b. $11.9°$
    c. $-52.2°$
    d. $-19.6°$

    Solution
    The sum of the horizontal components is

    $$F_{net,x} = (18N)\cos(-28°) + (96N)\cos(-175°) = -79.7416343N$$

    The sum of the vertical components is

    $$F_{net,y} = (18N)\sin(-28°) + (96N)\sin(-175°) = -16.8174394N$$

    The angle of the net force is

    $$\theta_{net} = \tan^{-1}(-16.8174394/-79.7416343) = -168.1°$$

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

    $$\theta_{eq} = 11.9°$$

    Or

    $$\theta_{eq} = -348.1°$$

18. **Problem**
    A box of mass 28 kg slides down a frictionless inclined plane. The angle of incline is $22°$ from the horizontal. What is the acceleration of the box?

    a. 3.7 m/s^2
    b. 3.0 m/s^2
    c. 2.2 m/s^2
    d. 3.4 m/s^2

    Solution
    The acceleration is

    $$a = g\sin\theta = (9.8\,\mathrm{m/s^2})\sin(22°) = 3.7\,\mathrm{m/s^2}$$

19. **Problem**
    A box of mass 12 kg slides down an inclined plane with friction. The angle of incline is $48°$ and $\mu_k = 0.55$. What is the acceleration of the box?

    a. 3.7 m/s^2
    b. 2.6 m/s^2
    c. 3.4 m/s^2
    d. 4.7 m/s^2

    Solution
    The acceleration is

    $$a = g(\sin\theta - \mu\cos\theta) = 3.7\,\mathrm{m/s^2}$$

20. **Problem**
An 4.5-kg box slides down a 44° inclined plane with constant acceleration. The box starts from rest at the top. At the bottom, its velocity reaches 4.61 m/s. The length of the incline is 2.75 m. What is the coefficient of kinetic friction between the box and the plane?

    a. 0.623
    b. 0.474
    c. 0.418
    d. 0.541

    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

$$a = \frac{v_f^2}{2d} = \frac{(4.61\,\mathrm{m/s})^2}{2(2.75\,\mathrm{m})} = 3.8640182\,\mathrm{m/s^2}$$

The acceleration down an inclined plane with friction is

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

Solving for μ

$$\mu = \tan\theta - \frac{a}{g\cos\theta} = \tan(44^\circ) - \frac{(3.8640182\,\mathrm{m/s^2})}{(9.80\,\mathrm{m/s^2})\cos(44^\circ)}$$

$$\mu = 0.418$$