UNIT 4 REVIEW: MORE PRACTICE WITH FORCES AND NEWTON'S LAWS ANSWER KEY

***INSTRUCTIONS**: Answer each question thoroughly. Use complete sentences where appropriate and remember to show your work completely (including the equation in variable form and a FBD)! This unit corresponds to Chapter 4 in your textbook.*

MULTIPLE CHOICE CONCEPTS:

1. Define each of Newton's 3 Laws of Motion.

   Newton's 1st Law: An object continues in constant motion unless an unbalanced force causes it to change. (i.e. – an object in motion stays in motion; an object at rest stays at rest)

   Newton's 2nd Law: A net force acting on an object causes an acceleration that is directly proportional to the force exerts and inversely proportional to the mass of the object. (i.e. - $F_{NET} = ma$)

   Newton's 3rd Law: Forces occur in pairs; the action and reaction forces have equal magnitudes and act in opposite directions.

2. What is inertia? How is it quantified for an object?

   Inertia is an object's resistance to any change in its motion. It is an inherent quality of the object; the mass of an object is an indication of the amount of inertia that object has.

3. What is the difference between mass and weight? Which can change with location?

   Mass is an inherent quality of an object based on the amount of matter it has; it is measured in kilograms (kg). Weight is the interaction between objects with mass defined as $F_g = mg$; it is a force so it is measured in Newtons (N). Weight is dependent on location while mass is not (your mass stays the same, regardless of location).

4. If a refrigerator weighs 1250 N, what is it's mass?

$$F_g = mg \rightsquigarrow m = \frac{F_g}{g} = \frac{1250\ \text{N}}{9.80\ {}^{\text{m}}/_{\text{s}^2}}$$

$$\boxed{m = 128\ \text{kg}}$$

5. Define static and dynamic equilibrium.

   Static equilibrium occurs when a system has a net force of 0 N and is at rest.

   Dynamic equilibrium occurs when a system has a net force of 0 N and is moving at a constant velocity (no acceleration).

6. What are the rules for drawing a FBD? How are forces' magnitudes and directions indicated?

   The object is represented by a large dot/box; all forces are indicated as arrows pointing AWAY from the object; the length of the arrow indicates magnitude and the direction represents the direction; always label the forces acting on the object.

7. A 20 N force and a 75 N force act on an object. What is the net force on the object if the forces act in the same direction? What is the magnitude of net force if the forces act in the opposite directions?

$$F_{NET} = F_1 + F_2 = 75\ \text{N} + 20\ \text{N} = \boxed{95\ \text{N}}$$

$$F_{NET} = F_1 - F_2 = 75\ \text{N} - 20\ \text{N} = \boxed{55\ \text{N}}$$

8. A net force acting on a cart will cause it to accelerate. If the same force is applied to a cart causes **three times** the acceleration, how do the masses compare?

According to Newton's 2nd Law, $F_{NET} = ma$. If the acceleration is 3 times as large, the mass, which is inversely proportional to acceleration, is ⅓ as large.

9. A child exerts a force of 62 N on a sled, accelerating it at 2.0 $^{\text{m}}/_{\text{s}^2}$. What is the mass of the sled?

$$F_{NET} = ma \rightsquigarrow m = \frac{F_{NET}}{a} = \frac{62\ \text{N}}{2.0\ ^{\text{m}}/_{\text{s}^2}}$$

$$\boxed{m = 31\ \text{kg}}$$

10. How much net force is needed to accelerate a 17 kg box to 5.0 $^{\text{m}}/_{\text{s}^2}$?

$$F_{NET} = ma = (17\ \text{kg})(5.0\ ^{\text{m}}/_{\text{s}^2})$$

$$\boxed{F_{NET} = 85\ \text{N}}$$

11. What is terminal velocity? What is the acceleration at terminal velocity?

Terminal velocity occurs when an object in free fall has reached its maximum speed. At this point, the weight of the object is balance by the force of air resistance acting on it. Thus net force is 0 N and it is no longer accelerating.

12. In an elevator, when do you feel heavier, lighter, and the same as when you are standing still?

You feel heavier when you're accelerating upwards (going up and speeding up or going down and slowing down)

You feel lighter when you're accelerating downwards (going up and slowing down or going down and speeding up)

You feel the same when you're not accelerating (constant velocity or at rest)

13. Do normal force (F_N) and weight (F_g) make up a 3rd law pair? Why or why not?

NO! The normal force is an interaction between an object and a surface, while weight is an interaction between the object and the Earth (or other astronomical body). There are not exactly two objects involved! Also, both forces are acting on the same object!

14. How do the magnitudes and directions of 3rd law pair forces compare?

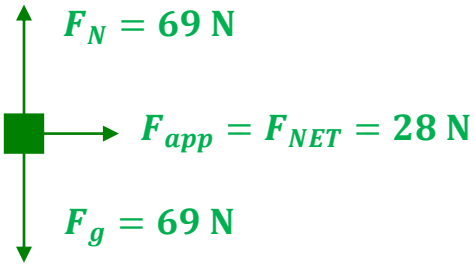
Their magnitudes are equal, but they act in opposite directions.

15. Does the Earth accelerate towards you when you accelerate towards the Earth? How do you know? How does the magnitude of the acceleration compare to your acceleration?

YES! The Earth experiences the same magnitude of force that you experience! The difference is the key here: the Earth is SO MASSIVE that it has a TINY acceleration up towards you. It's no noticeable, but it happens!

WRITTEN RESPONSE REVIEW:

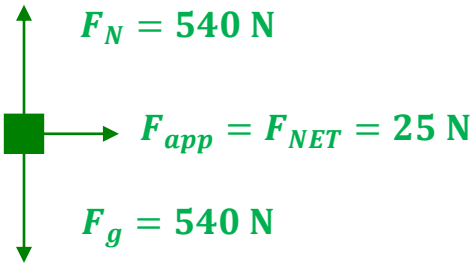
16. A 7.0 kg bowling ball is pushed in such a way that it accelerates at 4.0 $^{m}/_{s^2}$. Draw a quantitative free body diagram (using FBD rules!) for the bowling ball. Label all of the forces, with magnitudes, and determine the net force.



$$F_{NET} = ma = (7.0\text{ kg})\left(4.0\ {}^{m}/_{s^2}\right) = \boxed{28\text{ N}}$$

$$F_g = mg = (7.0\text{ kg})\left(9.80\ {}^{m}/_{s^2}\right) = \boxed{69\text{ N}}$$

17. A horizontal net force of 25 N is applied to a child on a bike. Assuming the child and bike have a mass of 55 kg, draw a quantitative FBD and determine the acceleration of the child in this situation.



$$F_g = mg = (55\text{ kg})\left(9.80\ {}^{m}/_{s^2}\right) = \boxed{540\text{ N}}$$

$$F_{NET} = ma \rightsquigarrow a = \frac{F_{NET}}{m} = \frac{25\text{ N}}{55\text{ kg}}$$

$$\boxed{a = 0.45\ {}^{m}/_{s^2}}$$

18. Pat is going on a bicycle ride! If the forward force provided by Pat's pedaling is 100N, and the combined force of friction and air drag is 30N, calculate:
    a. Pat's acceleration if his mass = 75kg.

$$F_{NET} = 100\text{ N} - 30\text{ N} = 70\text{ N}$$

$$F_{NET} = ma \rightsquigarrow a = \frac{F_{NET}}{m} = \frac{70\text{ N}}{75\text{ kg}}$$

$$\boxed{a = 0.9\ {}^{m}/_{s^2}}$$

b. Pat's velocity after 10 seconds if Pat started from rest.

$$v_2 = v_1 + at = 0 + \left(0.9\ {}^{\mathrm{m}}/_{\mathrm{s}^2}\right)(10\ \mathrm{s})$$

$$\boxed{v_2 = 9\ {}^{\mathrm{m}}/_{\mathrm{s}}}$$

19. A tow truck accelerates a car from rest to reach a speed of 25 $^{\mathrm{m}}/_{\mathrm{s}}$ in 11 seconds. If the applied force on the car is 870 N, what is the mass of the car?

$$a = \frac{v_2 - v_1}{t} = \frac{25\ {}^{\mathrm{m}}/_{\mathrm{s}} - 0\ {}^{\mathrm{m}}/_{\mathrm{s}}}{11\ s} = 2.3\ {}^{\mathrm{m}}/_{\mathrm{s}^2}$$

$$F_{NET} = ma \rightsquigarrow m = \frac{F_{NET}}{a} = \frac{870\ \mathrm{N}}{2.3\ {}^{\mathrm{m}}/_{\mathrm{s}^2}}$$

$$\boxed{m = 378\ \mathrm{kg}}$$

20. A rain drop falls from the sky. The mass of the rain drop is 9.0 grams. Initially it accelerates at a rate of 8.0 $^{\mathrm{m}}/_{\mathrm{s}^2}$.

a. What is the **force of air drag** on the rain drop at that moment? Sketch a FBD.

$$F_{NET} = ma = (0.009\ \mathrm{kg})\left(8.0\ {}^{\mathrm{m}}/_{\mathrm{s}^2}\right) = \underline{0.07\ \mathrm{N}}$$

$$F_g = mg = (0.009\ \mathrm{kg})\left(9.80\ {}^{\mathrm{m}}/_{\mathrm{s}^2}\right) = \boxed{0.09\ \mathrm{N}}$$

$$F_{NET} = F_g - F_{air\ drag} \rightsquigarrow F_{air\ drag} = F_g - F_{NET}$$

$$F_{air\ drag} = 0.09\ \mathrm{N} - 0.07\ \mathrm{N} = \boxed{0.02\ \mathrm{N}}$$

b. The rain drop has reached terminal (constant) velocity by the time it reaches you. What is the **force of air drag** on the rain drop at that moment? Sketch a FBD.

$$F_{NET} = ma = (0.009\ \mathrm{kg})\left(0\ {}^{\mathrm{m}}/_{\mathrm{s}^2}\right) = 0\ \mathrm{N}$$

$$\boxed{F_g = F_{air\ drag} = 0.09\ \mathrm{N}}$$

21. Which of the following statements is ALWAYS true of an object at equilibrium?

a. The object is at rest. ***FALSE***
b. The object is maintaining its state of motion. ***TRUE***
c. The object's velocity is not changing. ***TRUE***
d. The net force on the object is 0 Newtons. ***TRUE***
e. The object is NOT accelerating. ***TRUE***
f. The individual forces acting on the object are balanced. ***TRUE***
g. The individual forces acting on the object are equal in magnitude. ***FALSE***

22. The following statements were made about an object. In which case could you conclude that the object is at equilibrium?
    a. The object is at rest. ***TRUE***
    b. The object has a constant velocity. ***TRUE***
    c. The object is moving. ***FALSE***
    d. The object has a constant speed. ***FALSE***
    e. The object is stationary. ***TRUE***
    f. The acceleration of the object is 0 m/s/s. ***TRUE***
    g. All individual forces acting on the object are balanced. ***TRUE***