Learning Intentions

- To learn about the 4 fundamental forces
- To learn how to calculate the net force on an object
- To learn how to calculate the force of gravity between two objects

Notes

1. A force is a (vector / scalar) that describes a _____ or a _____ on an object.
2. There are _____ fundamental forces, a.k.a. (also known as) fundamental _____.

Fundamental Force	Definition
	Responsible for holding the positively-charged protons together in the _____ of the atom.
	The interaction that is responsible for the radioactive decay that occurs in nuclear _____.
	The phenomenon by which all things with mass or _____ (including light) are drawn towards each other.
	The push or pull experienced between _____ _____ particles.

3. Electrostatic forces are much (stronger / weaker) than gravitational forces.
4. Forces are measured in _____, which are equivalent to _____.
5. The _____ _____ is the sum of all the external forces on an object. It is a _____, not a real force.

6. A _____ _____ _____ (FBD) is used to model force by replacing the object with a single dot, and using _____ to indicate all the forces that are acting on the object.
    a. In Physics 11, we will assume all forces act through the _____ of _____ of the object, so there is no rotation.
    b. In Physics 12, the location of application of the force matters, as it can cause a _____ (or _____) that causes the object to rotate.
7. Draw a FBD of the following situations. Find the net force, including direction.
    a. A girl pushes a box to the left with a force of 45 N, while her twin brothers each push to the right with a force of 22 N. What is the net force on the box?

    b. Gravity pulls down on a bird with a force of 53 N. Each wing provides an upwards force of 33 N. What is the net force on the bird?

8. Universal Law of Gravitation:

    a. Note: The law is not actually universal. It was superseded by _____'s _____ Theory of _____.

Questions

1. The Earth has a mass of 5.97×10^{24} kg and a radius of 6.37×10^{6} m. What force does it exert on an object of mass 78 kg at the surface of the Earth?
2. What force does the Earth exert on an object of mass of 1.00 kg at the surface of the Earth?
3. What force does the Earth exert on an object of mass m_2 at the surface of the Earth?
4. Near the Earth's surface, the what is the force of gravity (**g**) in Newtons per kilogram (N/kg)?
5. If a 78 kg pilot in a turning plane experiences a force of 8 g's upwards, what is the force on the pilot in Newtons?
6. What is the force of gravity between two 1.0 kg masses 1.0 m apart?
7. The masses are moved so that they are 1.0 mm apart. What is the force of gravity between the masses?
8. The masses are moved so that they are at opposite "ends" of the universe, 93 billion light years apart. What is the force of gravity between the masses?
9. What will be the force of gravity on a 1.0 kg mass at the moon's surface? The moon has a mass of 7.35×10^{22} kg and a radius of 1,740 km.

See over →

10. How does $\mathbf{g}_{moon}$ compare to $\mathbf{g}_{Earth}$?

11. Using the Universal Law of Gravitation, find the force of gravity on a 1.0 kg mass on the International Space Station, which is located 400 km above the Earth's surface.

12. How does the force of gravity on the mass at the ISS compare with the force of gravity at the Earth's surface?

13. If there is still gravity at the ISS, why do astronauts float?

Answers

1. $\mathbf{F}_g$ = 760 N [towards Earth]
2. $\mathbf{F}_g$ = 9.81 N [towards Earth]
3. $\mathbf{F}_g$ = m_2 x 9.81 m/s^2 [towards Earth]
4. **g** = 9.81 N/kg [towards Earth] = -9.81 N/kg [up]
5. **F** = 6,000 N [upwards]
6. $\mathbf{F}_g$ = 6.7 x 10^{-11} N [towards each other]
7. $\mathbf{F}_g$ = 6.7 x 10^{-5} N [towards each other]
8. $\mathbf{F}_g$ = 8.6 x 10^{-65} N [towards each other]
9. $\mathbf{F}_g$ = 1.6 N [towards the moon]
10. $\mathbf{g}_{moon}$ = 0.16 $\mathbf{g}_{Earth}$
11. $\mathbf{F}_g$ = 8.7 N [towards Earth]
12. 88% of the force of gravity at the Earth's surface