Name ______________________ Class ______________ Date ______________

Assessment

Circular Motion and Gravitation

Section Quiz: Motion in Space

Write the letter of the correct answer in the space provided.

______ **1.** According to Copernicus, how do planets move?
  a. Planets move on small circles called epicycles while simultaneously orbiting Earth.
  b. Planets move in circular orbits around Earth.
  c. Planets move in circular orbits around the sun.
  d. Planets move in elliptical orbits with the sun at one focus.

______ **2.** Kepler's laws of planetary motion reconciled
  a. Ptolemaic theory with Copernican theory.
  b. Ptolemaic theory with Copernicus' data.
  c. Copernican theory with Newton's law of universal gravitation.
  d. Copernican theory with Tycho Brahe's data.

______ **3.** Which of the following correctly expresses Kepler's second law?
  a. Planets travel in elliptical orbits with the sun at one focus.
  b. A planet sweeps out equal areas of its orbit in equal time intervals.
  c. A planet's orbital period is proportional to the planet's distance from the sun.
  d. A planet's orbital period is independent of the planet's mass.

______ **4.** Which of the following correctly expresses Kepler's third law?
  a. $T \propto 1/r$
  b. $T^2 \propto r^2$
  c. $T^2 \propto r^3$
  d. $T^3 \propto r^2$

______ **5.** Newton's law of universal gravitation
  a. can be used to derive Kepler's third law of planetary motion.
  b. can be derived from Kepler's laws of planetary motion.
  c. can be used to disprove Kepler's laws of planetary motion.
  d. does not apply to Kepler's laws of planetary motion.

______ **6.** The speed of an object orbiting another object depends on
  a. only the mass of the orbiting object.
  b. only the mass of the object being orbited.
  c. the masses of each object and the distance between them.
  d. the mass of the object being orbited and the distance between the objects.

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______ **7.** How would the period of an object in a circular orbit change if the radius of the orbit doubled?
a. The period would increase by a factor of 2.
b. The period would decrease by a factor of 4.
c. The period would increase by a factor of $2\sqrt{2}$.
d. The period would decrease by a factor of $2\sqrt{2}$.

______ **8.** If you were to stand on a bathroom scale in an elevator that is accelerating downward, the bathroom scale would measure
a. your weight.
b. your mass.
c. the force due to gravity between you and Earth.
d. the normal force between you and the scale.

9. Explain why an astronaut in orbit experiences apparent weightlessness.

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10. A satellite with a mass of 2.5×10^3 kg orbits Earth at an altitude of 139 km. Calculate the orbital period and orbital speed of the satellite. ($m_E = 5.97 \times 10^{24}$ kg; $r_E = 6.38 \times 10^6$ m; $G = 6.673 \times 10^{-11}$ N•m^2/kg^2)

Solution

$m_1v_{1,i} + m_2v_{2,i} = m_1v_{1,f} + m_2v_{2,f}$

$$v_{2,f} = \frac{(m_1v_{1,i} + m_2v_{2,i} - m_1v_{1,f})}{m_2}$$

$v_2,f =$

$$\frac{(0.16\ \text{kg})(1.2\ \text{m/s}) + (0.16\ \text{kg})(-0.85\ \text{m/s}) - (0.16\ \text{kg})(-0.85\ \text{m/s})}{0.16\ \text{kg}}$$

$v_{2,f} = \boxed{1.2\ \text{m/s to the right}}$

$$KE_i = \frac{1}{2}mv_{1,i}^2 + \frac{1}{2}mv_{2,i}^2 = \frac{1}{2}(0.16\ \text{kg})(1.2\ \text{m/s})^2 + \frac{1}{2}(0.16\ \text{kg})(-0.85\ \text{m/s})^2$$

$KE_i = 0.12\ \text{J} + 0.058\ \text{J} = 0.18\ \text{J}$

$$KE_f = \frac{1}{2}mv^2{}_{1f} + \frac{1}{2}mv^2{}_{2f} = \frac{1}{2}(0.16\ \text{kg})(-0.85\ \text{m/s})^2 + \left(\frac{1}{2}\right)(0.16\ \text{kg})(1.2\ \text{m/s})^2$$

$KE_f = 0.058\ \text{J} + 0.12\ \text{J} = 0.18\ \text{J}$

$KE_i = KE_f$

7 Circular Motion and Gravitation

CIRCULAR MOTION

1. b
2. c
3. a
4. b
5. c
6. d
7. b
8. d
9. Friction between the car's tires and the road is the centripetal force that causes the car to move along a curved or circular path. Passengers in the car tend to lean or slide toward the outside of the turn because their inertia causes them to tend toward moving in a straight-line path.
10. $a_c = 0.83\ \text{m/s}^2$; $F_c = 1.1 \times 10^3\ \text{N}$

Given

$v_t = 2.5\ \text{m/s}$
$r = 7.5\ \text{m}$
$m = 1.3 \times 10^3\ \text{kg}$

Solution

$$a_c = \frac{v_t^2}{r} = \frac{(2.5\ \text{m/s})^2}{7.5\ \text{m}} = \boxed{0.83\ \text{m/s}^2}$$

$$F_c = \frac{mv_t^2}{r} = \frac{(1.3 \times 10^3\ \text{kg})(2.5\ \text{m/s})^2}{7.5\ \text{m}} = \boxed{1.1 \times 10^3\ \text{N}}$$

7 Circular Motion and Gravitation

NEWTON'S LAW OF UNIVERSAL GRAVITATION

1. b
2. c
3. a
4. c
5. d
6. a
7. d
8. d
9. Weight is the product of mass and gravitational field strength. An astronaut weighs less on the moon than on Earth because the gravitational field strength at the moon's surface is less than the gravitational field strength on Earth's surface.
10. $1.4 \times 10^2\ \text{N}$

Given

$m_1 = 7.35 \times 10^{22}\ \text{kg}$
$m_2 = 85\ \text{kg}$
$r = 1.74 \times 10^6\ \text{m}$
$G = 6.673 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2$

Solution

$$F_g = G\frac{m_1m_2}{r^2} = (6.673 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2) \times \frac{(7.35 \times 10^{22}\ \text{kg})(85\ \text{kg})}{(1.74 \times 10^6\ \text{m})^2} = \boxed{1.4 \times 10^2\ \text{N}}$$

7 Circular Motion and Gravitation

MOTION IN SPACE

1. c
2. d
3. b
4. c
5. a
6. d
7. c
8. d
9. The astronaut is in free fall at the same rate of acceleration as his or her surroundings.
10. $r = 5240\ \text{s}$; $V_t = 7820\ \text{m/s}$

Given

$altitude = 139\ \text{km} = 1.39 \times 10^5\ \text{m}$
$r_E = 1.74 \times 10^6\ \text{m}$
$m_E = 5.97 \times 10^{24}\ \text{kg}$
$G = 6.673 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2$

Solution

$r = altitude + r_E = (1.39 \times 10^5\ \text{m}) + (6.38 \times 10^6\ \text{m}) = 6.52 \times 10^6\ \text{m}$

$$T = 2\pi\sqrt{\frac{r^3}{Gm}} =$$

$$2\pi\sqrt{\frac{(6.52 \times 10^6 \text{ m})^3}{(6.673 \times 10^{-11} \text{ N}\bullet\text{m}^2/\text{kg}^2)(5.97 \times 10^{24} \text{ kg})}}$$

$= 5240$ s

$$v_t = \sqrt{G\frac{m}{r}} =$$

$$(6.673 \times 10^{-11} \text{ N}\bullet\text{m}^2/\text{kg}^2) \times \frac{(5.97 \times 10^{24} \text{ kg})}{(6.52 \times 10^6 \text{ m})} = \boxed{7820 \text{ m/s}}$$

7 Circular Motion and Gravitation

TORQUE AND SIMPLE MACHINES

1. d
2. a
3. d
4. b
5. b
6. c
7. b
8. d
9. In order for a machine to have 100% efficiency, the machine would have to be totally frictionless. Because any real machine has some friction, some of the energy input into a real machine is converted to nonmechanical forms of energy. As a result, the work output is always less than the work input.
10. 97 cm from the right end

Given

$m_1 = 35$ kg

$m_2 = 85$ kg

$d_1 = -1.50 \text{ m} + 0.20 \text{ m} = -1.30 \text{ m}$

$g = -9.81 \text{ m/s}^2$

Solution

$F_1 = m_1 g = (35 \text{ kg})(-9.81 \text{ m/s}^2) = -340 \text{ N}$

$F_2 = m_2 g = (85 \text{ kg})(-9.81 \text{ m/s2}) = -830 \text{ N}$

$\tau_{net} = F_1 d_1 + F_2 d_2 = 0$

$F_2 d_2 = -F_1 d_1$

$$d_2 = \frac{-F_1 d_1}{F_2} = \frac{-(-340 \text{ N})(-1.30 \text{ m})}{(-830 \text{ N})}$$

$= 0.53$ m

$d = 1.50 \text{ m} - 0.53 \text{ m} = 0.97 \text{ m} =$ $\boxed{\text{97 cm from the right end}}$

8 Fluid Mechanics

FLUIDS AND BUOYANT FORCE

1. a
2. d
3. a
4. d

Given

weight of displaced water $= F_g = 10.0$ N

5. b
6. c
7. c
8. a
9. Fluids do not possess definite shape, because the atoms or molecules in the fluid are free to move past each other. Ice is a solid in which the water molecules are bound together in a crystalline arrangement that prevents their moving past each other. Ice therefore has definite a shape, and does not flow. The molecules in liquid water or steam are able to move past each other, so that liquid water or steam flows and has no definite shape, and therefore is a fluid.
10. 2.2×10^{-2} N

The metal is more dense than the salt water, so it is completely submerged. The volume of the displaced salt water (V_{sw}) equals the volume of the metal (V_m).

Given

$\rho_{sw} = 1.025 \times 10^3 \text{ kg/m}^3$

$\ell = 1.3$ cm

$g = 9.81 \text{ m/s}^2$

Solution

$F_b = \rho_{sw} V_{sw} g = \rho_{sw} V_m g = \rho_{sw} \ell^3 g$

$$F_b = (1.025 \times 10^3 \text{ kg/m}^3)(1.3 \text{ cm})^3 (9.81 \text{ m/s}^2) \times \left(\frac{1\text{m}}{100 \text{ cm}}\right)^3$$

$F_b = \boxed{2.2 \times 10^{-2} \text{ N}}$

8 Fluid Mechanics

FLUID PRESSURE

1. c
2. a
3. c

Given

$P = 8.0 \times 10^4$ Pa

$A = 1.0 \times 10^{-2} \text{ m}^2$

Solution

$F = PA = (8.0 \times 10^4 \text{ Pa})(1.0 \times 10^{-2} \text{ m}^2) = 8.0 \times 10^2 \text{ N}$

4. b