

- 1 Two spherical objects have masses of 200 kg and 500 kg. Their centers are separated by a distance of 25 m. Find the gravitational attraction between them.**

**2 Two spherical objects have masses of  $1.5 \times 10^5$  kg and  $8.5 \times 10^2$  kg. Their centers are separated by a distance of 2500 m. Find the gravitational attraction between them.**

- 3 Two spherical objects have masses of  $3.1 \times 10^5$  kg and  $6.5 \times 10^3$  kg. The gravitational attraction between them is 65 N. How far apart are their centers?**

- 4 Two spherical objects have equal masses and experience a gravitational force of 25 N towards one another. Their centers are 36cm apart. Determine each of their masses.**

**5 A 1 kg object is located at a distance of  $6.4 \times 10^6$  m from the center of a larger object whose mass is  $6.0 \times 10^{24}$  kg.**

- ☐ **A What is the size of the force acting on the smaller object?**
- ☐ **B What is the size of the force acting on the larger object?**
- ☐ **C What is the acceleration of the smaller object when it is released?**
- ☐ **D What is the acceleration of the larger object when it is released?**

- 6 Two spherical objects have masses of 8000 kg and 1500 kg. Their centers are separated by a distance of 1.5 m. Find the gravitational attraction between them.**

- 7 Two spherical objects have masses of  $7.5 \times 10^5$  kg and  $9.2 \times 10^7$  kg. Their centers are separated by a distance of  $2.5 \times 10^3$  m. Find the gravitational attraction between them.**

**8 Two spherical objects have masses of  $8.1 \times 10^2$  kg and  $4.5 \times 10^8$  kg. The gravitational attraction between them is  $1.9 \times 10^{-3}$  N. How far apart are their centers?**



- 9 Two spherical objects have equal masses and experience a gravitational force of 85 N towards one another. Their centers are 36mm apart. Determine each of their masses.**

**10 A 1 kg object is located at a distance of  $7.0 \times 10^8$  m from the center of a larger object whose mass is  $2.0 \times 10^{30}$  kg.**

- ☐ **A What is the size of the force acting on the smaller object?**
- ☐ **B What is the size of the force acting on the larger object?**
- ☐ **C What is the acceleration of the smaller object when it is released**
- ☐ **D What is the acceleration of the larger object when it is released?**

- 11 Two spherical objects have masses of 8000 kg and 5.0 kg. Their centers are separated by a distance of 1.5 m. Find the gravitational attraction between them.**

**12 Two spherical objects have masses of  $9.5 \times 10^8$  kg and 2.5 kg. Their centers are separated by a distance of  $2.5 \times 10^8$  m. Find the gravitational attraction between them.**

**13 Two spherical objects have masses of  $6.3 \times 10^3$  kg and  $3.5 \times 10^4$  kg. The gravitational attraction between them is  $6.5 \times 10^{-3}$  N. How far apart are their centers?**

- 14 Two spherical objects have equal masses and experience a gravitational force of 25 N towards one another. Their centers are 36 cm apart. Determine each of their masses.**

**15 A 1 kg object is located at a distance of  $1.7 \times 10^6$  m from the center of a larger object whose mass is  $7.4 \times 10^{22}$  kg.**

- ☐ **A What is the size of the force acting on the smaller object?**
- ☐ **B What is the size of the force acting on the larger object?**
- ☐ **C What is the acceleration of the smaller object when it is released?**
- ☐ **D What is the acceleration of the larger object when it is released?**

**16   \*Compute  $g$  at a distance of  $4.5 \times 10^7 \text{ m}$  from the center of a spherical object whose mass is  $3.0 \times 10^{23} \text{ kg}$ .**



**17   \*Compute  $g$  for the surface of the moon. Its radius is  $1.7 \times 10^6$  m and its mass is  $7.4 \times 10^{22}$  kg.**

- 18   \*Compute  $g$  for the surface of a planet whose radius is twice that of the Earth and whose mass is the same as that of the Earth.**

**19    \*Compute  $g$  for the surface of the sun. Its radius is  $7.0 \times 10^8$  m and its mass is  $2.0 \times 10^{30}$  kg.**

**20    \*Compute  $g$  for the surface of Mars. Its radius is  $3.4 \times 10^6$  m and its mass is  $6.4 \times 10^{23}$  kg.**

**21   \*Compute  $g$  at a height of  $6.4 \times 10^6 \text{ m}$  ( $R_E$ ) above the surface of Earth.**

**22   \*Compute  $g$  at a height of  $2 R_E$  above the surface of Earth.**

**23   \*Compute  $g$  for the surface of a planet whose radius is half that of the Earth and whose mass is double that of the Earth.**

**24   \*Compute  $g$  at a distance of  $8.5 \times 10^9 \text{ m}$  from the center of a spherical object whose mass is  $5.0 \times 10^{28} \text{ kg}$ .**



**25   \*Compute  $g$  at a distance of  $7.3 \times 10^8$  m from the center of a spherical object whose mass is  $3.0 \times 10^{27}$  kg.**

**26    \*Compute  $g$  for the surface of Mercury. Its radius is  $2.4 \times 10^6$  m and its mass is  $3.3 \times 10^{23}$  kg.**

**27    \*Compute  $g$  for the surface of Venus. Its radius is  $6.0 \times 10^6$  m and its mass is  $4.9 \times 10^{24}$  kg.**

**28   \*Compute  $g$  for the surface of Jupiter. Its radius of is  $7.1 \times 10^7$  m and its mass is  $1.9 \times 10^{27}$  kg.**

**29   \*Compute  $g$  at a height of  $4 R_E$  above the surface of Earth.**

**30   \*Compute  $g$  at a height of  $5 R_E$  above the surface of Earth.**

**31   \*Compute  $g$  for the surface of a planet whose radius is double that of the Earth and whose mass is also double that of the Earth.**

## **32 Compute:**

- a) The velocity of an object orbiting at a distance of  $4.5 \times 10^7$  m from the center of a spherical object whose mass is  $3.0 \times 10^{23}$  kg.**
- b) Compute the orbital period of that object.**



### **33 Compute:**

- a) The velocity of an object orbiting at a height of  $6.4 \times 10^6$  m above the surface of Earth.**
- b) Compute the orbital period of that object.**

**34 Mars has two moons, Phobos and Deimos. Phobos has an orbital radius of  $9.4 \times 10^6$  m and an orbital period of 0.32 days. Deimos has an orbital radius of  $23.5 \times 10^6$  m.**

**a) What is the orbital period of Deimos?**

**b) At what height above the surface of Mars would a satellite have to be placed so that it remains above the same location on the surface of Mars as the planet rotates below it. A Martian day is equal to 1.02 Earth days.**

## **35 Compute:**

- a) The velocity of an object orbiting at a distance of  $8.5 \times 10^9 \text{ m}$  from the center of a spherical object whose mass is  $5.0 \times 10^{28} \text{ kg}$ .**
- b) Compute the orbital period of that object.**

## **36 Compute:**

- a) The velocity of an object orbiting at height of  $2 R_E$  above the surface of Earth.**
- b) Compute the orbital period of that object.**

**37 Earth orbits the sun in 365.25 days and has an orbital radius of  $1.5 \times 10^{11}$  m.**

**a) How many days will it take Mercury to orbit the sun given that its orbital radius is  $5.8 \times 10^{10}$  m?**

**b) How many days will it take Mars to orbit the sun given that its orbital radius is  $2.3 \times 10^{11}$  m?**

**c) It takes Jupiter 4333 days to orbit the sun. What is the average distance from the sun?**

**38 Compute:**

- a) The velocity of an object orbiting at a distance of  $7.3 \times 10^8$  m from the center of a spherical object whose mass is  $3.0 \times 10^{27}$  kg.**
- b) Compute the orbital period of that object.**

### **39 Compute:**

- a) The velocity, both magnitude and direction, of an object orbiting at a height of  $5 R_E$  above the surface of Earth.**
- b) Compute the orbital period of that object.**

**40 Calculate the orbital velocity and the period, in days, for an object orbiting the sun at distance of  $1.5 \times 10^{11}$  m. Give the period in days.**



**41 Jupiter has 16 moons. One of them, Io, has an orbital radius of  $4.2 \times 10^8$  m and an orbital period of 1.77 days.**

**a) What is the mass of Jupiter?**

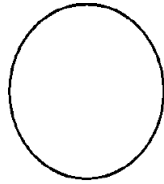
**b) Another of them, Europa, has an orbital radius of  $6.7 \times 10^8$  m. What is its orbital period?**

**c) Another of them, Ganymede, has an orbital period 7.2 days. What is the radius of its orbit?**

**d) Jupiter rotates once every 0.41 days. At what orbital radius will a satellite maintain a constant position?**

# General Problems

**42. As shown in the diagram below, a 5.0 kg space rock is located  $2.5 \times 10^7$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



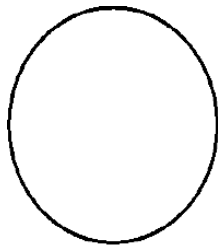
Earth



Space Rock

- Determine the force of gravity acting on the space rock, due to the earth. Calculate the magnitude and state the direction.**
- Compare your answer in a) to the force of gravity acting on the earth, due to the space rock. Indicate that force on the diagram above.**
- On the diagram above, indicate the direction the space rock would accelerate if released. Label that vector “a”.**
- Calculate the acceleration the rock would experience.**
- \*\*If instead of falling, the object were in a stable orbit, indicate on the diagram above a possible direction of its velocity. Label that vector “v”.**
- \*\*Calculate the velocity the rock needs to be in a stable orbit.**
- \*\*Calculate the period of the rock orbiting the earth.**

**42. As shown in the diagram below, a 5.0 kg space rock is located  $2.5 \times 10^7$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



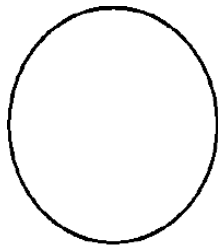
Earth



Space Rock

- a. Determine the force of gravity acting on the space rock, due to the earth. Calculate the magnitude and state the direction.**

**42. As shown in the diagram below, a 5.0 kg space rock is located  $2.5 \times 10^7$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



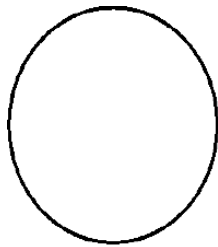
Earth



Space Rock

**b. Compare your answer in a) to the force of gravity acting on the earth, due to the space rock. Indicate that force on the diagram above.**

**42. As shown in the diagram below, a 5.0 kg space rock is located  $2.5 \times 10^7$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



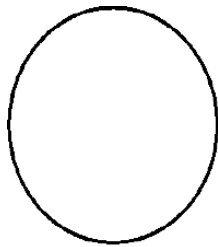
Earth



Space Rock

**c. On the diagram above, indicate the direction the space rock would accelerate if released. Label that vector “a”.**

**42. As shown in the diagram below, a 5.0 kg space rock is located  $2.5 \times 10^7$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



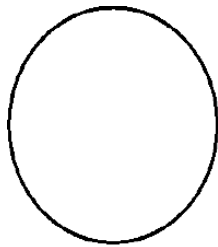
Earth



Space Rock

**d. Calculate the acceleration the rock would experience.**

**42. As shown in the diagram below, a 5.0 kg space rock is located  $2.5 \times 10^7$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



Earth

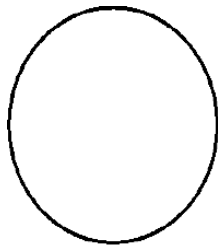


Space Rock

**e. \*\*If instead of falling, the object were in a stable orbit, indicate on the diagram above a possible direction of its velocity. Label that vector “v”.**



**42. As shown in the diagram below, a 5.0 kg space rock is located  $2.5 \times 10^7$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



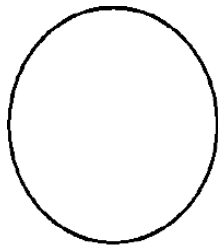
Earth



Space Rock

**f. \*\*Calculate the velocity the rock needs to be in a stable orbit.**

**42. As shown in the diagram below, a 5.0 kg space rock is located  $2.5 \times 10^7$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



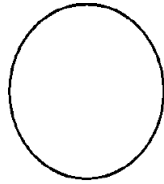
Earth



Space Rock

**g. \*\*Calculate the period of the rock orbiting the earth.**

**43. As shown in the diagram below, a 2000 kg spacecraft is located  $9.2 \times 10^6$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



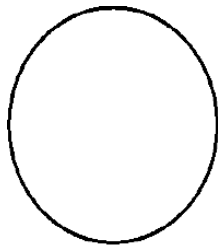
Earth



Space Rock

- Determine the force of gravity acting on the spacecraft, due to the earth. Calculate the magnitude and state the direction.**
- Compare your answer in a) to the force of gravity acting on the earth, due to the spacecraft. Indicate that force on the diagram above.**
- On the diagram above, indicate the direction the spacecraft would accelerate if released. Label that vector “a”.**
- Calculate the acceleration the spacecraft would experience.**
- \*\*If instead of falling, the spacecraft were in a stable orbit, indicate on the diagram above a possible direction of its velocity. Label that vector “v”.**
- \*\*Calculate the velocity the spacecraft needs to be in a stable orbit.**
- \*\*Calculate the period of the rock orbiting the earth.**

**43. As shown in the diagram below, a 2000 kg spacecraft is located  $9.2 \times 10^6$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



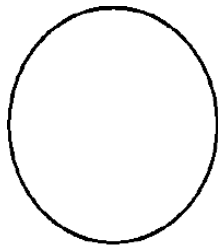
Earth



Space Rock

**a. Determine the force of gravity acting on the spacecraft, due to the earth. Calc the magnitude and state the direction.**

**43. As shown in the diagram below, a 2000 kg spacecraft is located  $9.2 \times 10^6$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



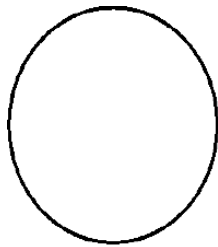
Earth



Space Rock

**b. Compare your answer in a) to the force of gravity acting on the earth, due to the spacecraft. Indicate that force on the diagram above.**

**43. As shown in the diagram below, a 2000 kg spacecraft is located  $9.2 \times 10^6$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



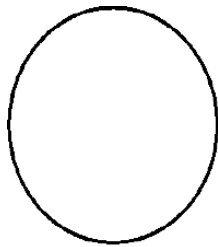
Earth



Space Rock

**c. On the diagram above, indicate the direction the spacecraft would accelerate if released. Label that vector “a”.**

**43. As shown in the diagram below, a 2000 kg spacecraft is located  $9.2 \times 10^6$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



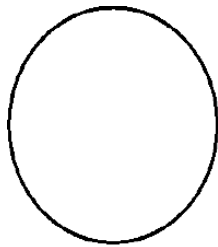
Earth



Space Rock

**d. Calculate the acceleration the spacecraft would experience.**

**43. As shown in the diagram below, a 2000 kg spacecraft is located  $9.2 \times 10^6$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



Earth

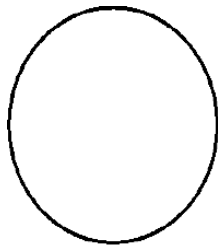


Space Rock

**e. \*\*If instead of falling, the spacecraft were in a stable orbit, indicate on the diagram above a possible direction of its velocity. Label that vector “v”.**



**43. As shown in the diagram below, a 2000 kg spacecraft is located  $9.2 \times 10^6$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



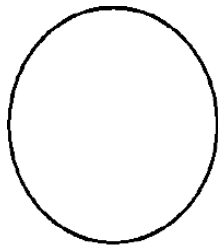
Earth



Space Rock

**f. \*\*Calculate the velocity the spacecraft needs to be in a stable orbit.**

**43. As shown in the diagram below, a 2000 kg spacecraft is located  $9.2 \times 10^6$  m from the center of the earth. The mass of the earth is  $6.0 \times 10^{24}$  kg.**



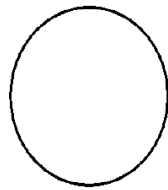
Earth



Space Rock

**g. \*\*Calculate the period of the rock orbiting the earth.**

**44. As shown in the diagram below, a 1000 kg asteroid is located  $6.8 \times 10^6$  m from the center of the Mars. The mass of the Mars is  $6.4 \times 10^{23}$  kg.**



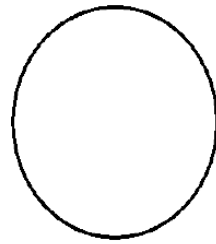
Mars



Asteroid

- Determine the force of gravity acting on the asteroid, due to the Mars. Calculate the magnitude and state the direction.**
- Compare your answer in a) to the force of gravity acting on the Mars, due to the asteroid. Indicate that force on the diagram above.**
- On the diagram above, indicate the direction the asteroid would accelerate if released. Label that vector “a”.**
- Calculate the acceleration the asteroid would experience.**
- \*\*If instead of falling, the asteroid were in a stable orbit, indicate on the diagram above a possible direction of its velocity. Label that vector “v”.**
- \*\*Calculate the velocity the asteroid needs to be in a stable orbit.**
- \*\*Calculate the period of the asteroid orbiting the earth.**

**44. As shown in the diagram below, a 1000 kg asteroid is located  $6.8 \times 10^6$  m from the center of the Mars. The mass of the Mars is  $6.4 \times 10^{23}$  kg.**



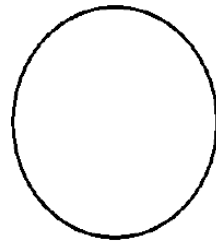
Mars



Asteroid

- a. Determine the force of gravity acting on the asteroid, due to the Mars. Calculate the magnitude and state the direction.**

**44. As shown in the diagram below, a 1000 kg asteroid is located  $6.8 \times 10^6$  m from the center of the Mars. The mass of the Mars is  $6.4 \times 10^{23}$  kg.**



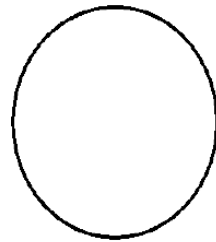
Mars



Asteroid

**b. Compare your answer in a) to the force of gravity acting on the Mars, due to the asteroid. Indicate that force on the diagram above.**

**44. As shown in the diagram below, a 1000 kg asteroid is located  $6.8 \times 10^6$  m from the center of the Mars. The mass of the Mars is  $6.4 \times 10^{23}$  kg.**



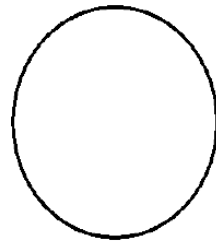
Mars



Asteroid

**c. On the diagram above, indicate the direction the asteroid would accelerate if released. Label that vector “a”.**

**44. As shown in the diagram below, a 1000 kg asteroid is located  $6.8 \times 10^6$  m from the center of the Mars. The mass of the Mars is  $6.4 \times 10^{23}$  kg.**



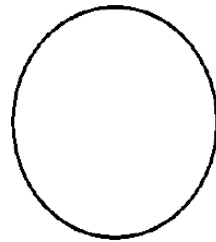
Mars



Asteroid

**d. Calculate the acceleration the asteroid would experience.**

**44. As shown in the diagram below, a 1000 kg asteroid is located  $6.8 \times 10^6$  m from the center of the Mars. The mass of the Mars is  $6.4 \times 10^{23}$  kg.**



Mars

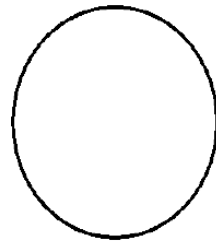


Asteroid

**e. \*\*If instead of falling, the asteroid were in a stable orbit, indicate on the diagram above a possible direction of its velocity. Label that vector “v”.**



**44. As shown in the diagram below, a 1000 kg asteroid is located  $6.8 \times 10^6$  m from the center of the Mars. The mass of the Mars is  $6.4 \times 10^{23}$  kg.**



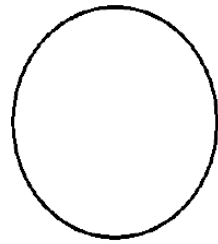
Mars



Asteroid

**f. \*\*Calculate the velocity the asteroid needs to be in a stable orbit.**

**44. As shown in the diagram below, a 1000 kg asteroid is located  $6.8 \times 10^6$  m from the center of the Mars. The mass of the Mars is  $6.4 \times 10^{23}$  kg.**



Mars



Asteroid

**g. \*\*Calculate the period of the asteroid orbiting the earth.**