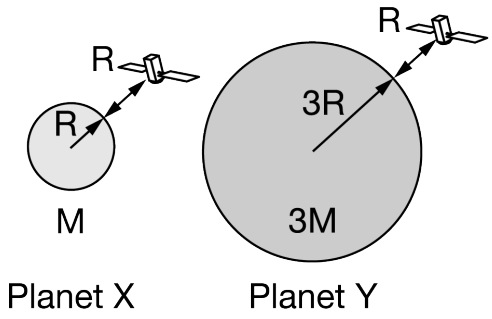
Unit 3 Progress Check: MCQ Part A



Planet X has a mass of M and a radius of R. Planet Y has a mass of $3M$ and a radius of $3R$. Identical satellites orbit both planets at a distance R above their surfaces, as shown above. The planets are separated by such a large distance that the gravitational forces between them are negligible.

1. How does the magnitude of the gravitational force F_Y exerted by Planet Y on its satellite compare to the gravitational force F_X exerted by Planet X on its satellite?

(A) $F_Y = 3F_X$

(B) $F_Y = \frac{3}{2}F_X$

(C) $F_Y = \frac{3}{4}F_X$ ✓

(D) $F_Y = \frac{1}{3}F_X$

2. How does the gravitational field g_X at the surface of Planet X compare with the gravitational field g_Y at the surface of Planet Y?

(A) $g_X = 9g_Y$

(B) $g_X = 3g_Y$ ✓

(C) $g_X = \frac{1}{3}g_Y$

(D) $g_X = \frac{1}{9}g_Y$

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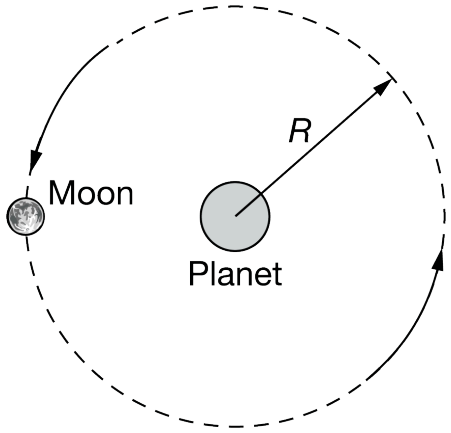
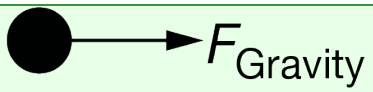
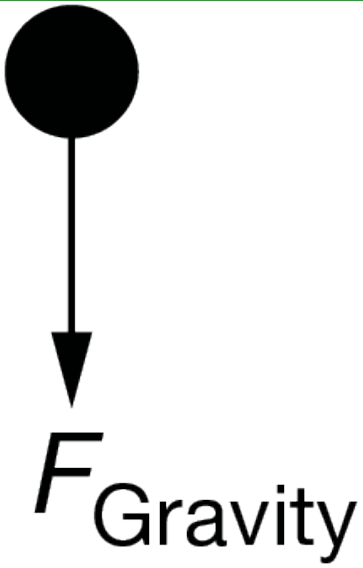
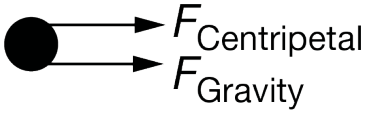


A moon orbits a planet in a nearly circular orbit of radius R, as shown in the figure.

3. Which of the following free-body diagrams could be used to analyze the forces exerted on the moon when it is at the position indicated in the figure?

(A) 

(B) 

(C) 

(D) 

4. The moon has a mass of 1×10^{22} kg, and the gravitational field strength at a distance R from the planet is $0.001\ \mathrm{N/kg}$. What is the gravitational force exerted on the moon while it is in orbit around the planet?

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(A) $0\,\text{N}$

(B) $1 \times 10^{19}\,\text{N}$ ✓

(C) $1 \times 10^{22}\,\text{N}$

(D) $1 \times 10^{25}\,\text{N}$

5. Astronomers making careful observations of the moon's orbit discover that the orbit is not perfectly circular, nor is it elliptical. Which of the following statements supports this observation?

(A) The moon and the planet exert forces of equal magnitude on each other.

(B) There is another celestial body that exerts a gravitational force on the moon. ✓

(C) The value of the gravitational constant G is different in the location near the planet-moon system.

(D) There is a centripetal force that causes the net force exerted on the moon to be different from the gravitational force.

6.

Figure 1

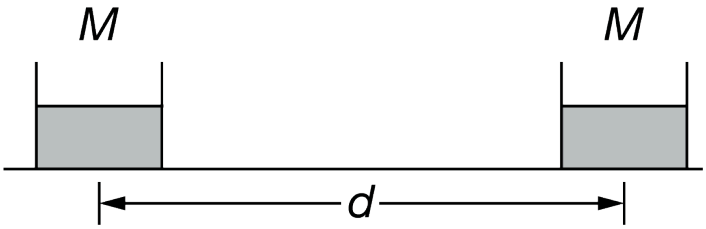
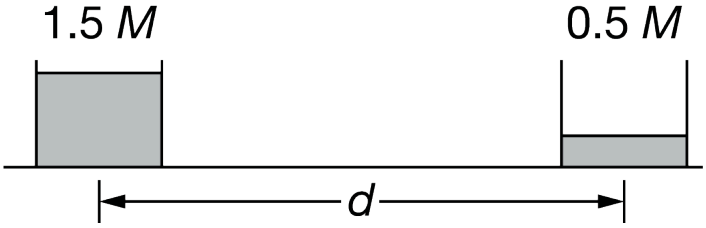


Figure 2



Two containers of water can have their individual masses varied by adding or removing water. The containers are initially a distance d apart, as measured from their centers, and are filled with water so that each has a mass M, as shown in Figure 1 above. The gravitational force that one container exerts on the other is F_0. Water is then added to one container so that its mass increases to $1.5M$, and water is removed from the other container so that its mass decreases to $0.5M$, as shown in Figure 2. What is the new gravitational force exerted on one container by the other?

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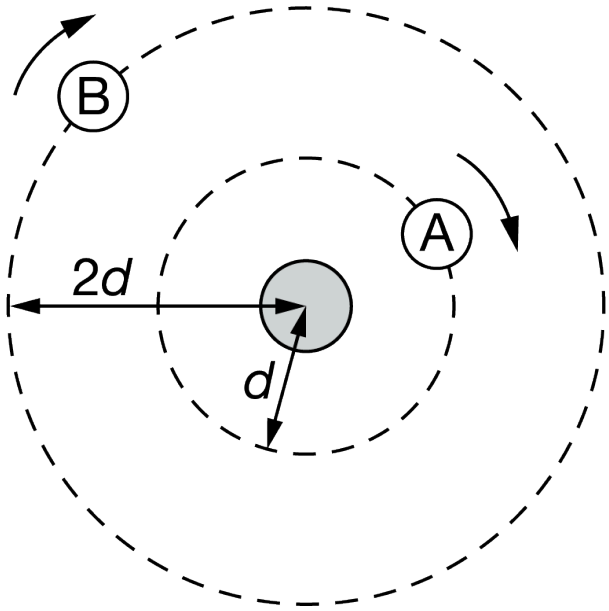
(A) $\frac{3}{4}F_0$ ✓

(B) F_0

(C) $\frac{3}{2}F_0$

(D) $2F_0$

7.



Satellite A orbits a planet at a distance d from the planet's center with a centripetal acceleration a_0. A second identical satellite B orbits the same planet at a distance $2d$ from the planet's center with centripetal acceleration a_b. What is the centripetal acceleration a_b in terms of a_0 ?

(A) $a_0/4$ ✓

(B) $a_0/2$

(C) $2a_0$

(D) $4a_0$

8. A student must conduct two experiments so that the inertial mass and gravitational mass of the same object can be determined. In the experiment to find the object's gravitational mass, the student ties one end of a string around the object with the other end tied to a spring scale so that the object can vertically hang at rest. In the experiment to find the object's inertial mass, the student uses a spring scale to pull the object, starting from rest, across a horizontal surface with a constant applied force such that frictional forces are considered to be negligible. In addition to the spring scale, the student has access to other measuring devices commonly found in a science laboratory. Which of the following lists the essential measuring devices the student can use to collect the data necessary to find the object's gravitational and inertial mass?

(A) Meterstick and timer ✓

(B) Meterstick, timer, and motion detector

(C) Meterstick, timer, motion detector, and mass balance

(D) Meterstick, timer, motion detector, mass balance, and protractor

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9. Two experiments are conducted are conducted to determine the mass of an object. In Experiment 1, the object's weight is measured by using an electronic balance once the object has been placed at rest on the balance. In Experiment 2, the object is pulled along a horizontal surface with a spring scale such that the force reading on the spring scale remains constant while a motion detector is used to measure the instantaneous speed of the object as it is pulled. All frictional forces for both experiments are considered to be negligible. Which of the two experiments, if either, could be used to determine the gravitational mass of the object?

(A) Experiment 1 only ✓

(B) Experiment 2 only

(C) both experiments

(D) neither experiment

10. A student analyzes data of the motion of a planet as it orbits a star that is in deep space. The orbit of the planet is considered to be stable and does not change over time. The student claims, “The only experimentally measurable external force exerted on the planet is the force due to gravity from the star.” Is the student’s claim supported by the evidence? What reasoning either supports or contradicts the student’s claim?

(A) Yes. Other external forces are exerted on the planet, but they are of negligible magnitude. ✓

(B) Yes. The only external force exerted on the planet is the force due to gravity from the star.

(C) No. The strong nuclear forces, weak nuclear forces, and the electromagnetic forces exerted on the planet could be measured.

(D) No. There are no external forces exerted on the planet.

11. An object is placed on a rotating disk. The amount of time it takes the object to make one revolution around the center of the circle may be set at a known value. Which of the following procedures could be used to make the necessary measurements to find the coefficient of static friction between the object and the disk’s surface?

(A) Place the object on the edge of the disk. Set the disk to rotate at a tangential speed for the object such that the object does not slide. Use a stopwatch to measure the time it takes for the object to make one revolution. Use a balance to determine the mass of the object.

(B) Place the object on the disk and measure the distance from the center of the disk to the center of mass of the object by using a meterstick. Slowly increase the rate the disk rotates until the object begins to slide off the disk. Record the time in which the object makes one revolution around the center of the disk. Use a balance to determine the mass of the object.

(C) Place the object on the disk. Use a motion sensor placed above the disk to measure the tangential speed the object rotates just after the mass begins to slide while increasing the rate at which the disk rotates. Use a balance to determine the mass of the object.

(D) Place the object on the disk and measure the distance from the center of the disk to the center of mass of the object by using a meterstick. Slowly increase the rate the disk rotates until the object begins to slide off the disk. Record the time in which the object makes one revolution around the center of the disk. ✓

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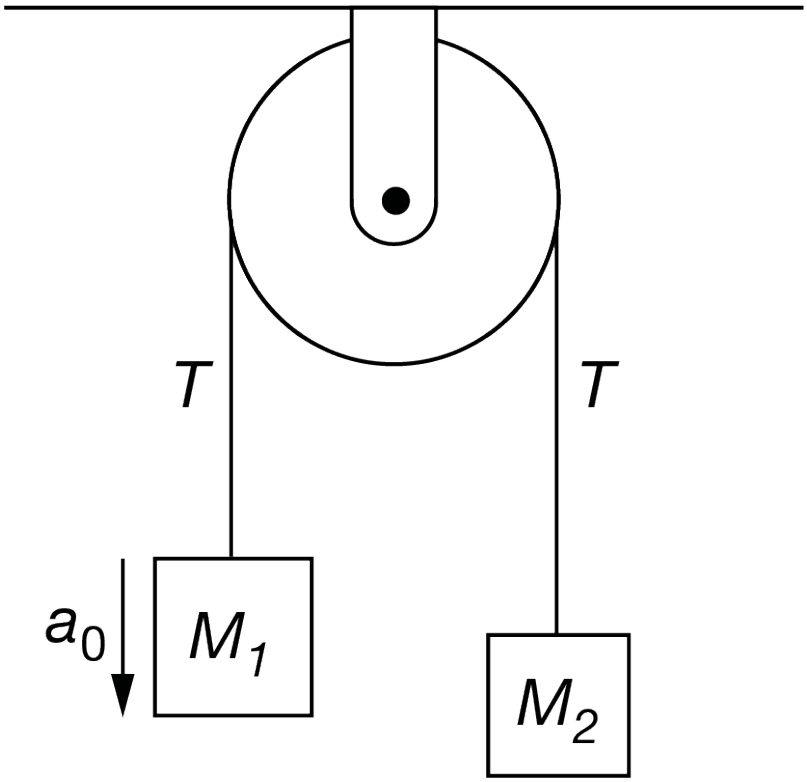
12.



An Atwood machine is placed on a planet in which the acceleration due to gravity on the planet is unknown. Both ends of a light string are attached to two blocks such that $M_1 > M_2$, and the string passes through a pulley such that frictional forces are considered to be negligible, as shown above. The same tension force T is exerted on both blocks, and the block of mass M_1 experiences an acceleration a_0 in the downward direction when released from rest. Which quantities would allow the acceleration due to gravity on the planet to be determined?

(A) M_1 , M_2 , and a_0 ✓

(B) T and M_1 only

(C) a_0 and M_1 only

(D) a_0 only

13. A scientist designs an experiment that requires two atomic particles whose only fundamental force exerted between them is the gravitational force. Which combination of particles and separation distance will meet this condition?

(A) A proton and neutron within an atomic nucleus

(B) A proton and electron within the same atom

(C) A proton and neutron located 1.0 mm apart ✓

(D) A proton and electron located 1.0 cm apart

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14.

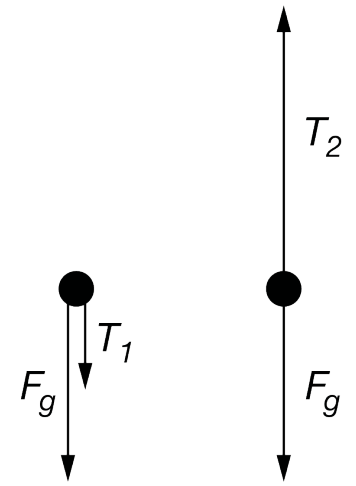

Figure 1 Figure 2

A ball of Mass M is swung in a vertical circle with a constant tangential speed. Figure 1 shows the forces exerted on the ball at the top of the circle, and Figure 2 shows the forces exerted on the ball at the bottom of the circle. Which of the following is an expression for the centripetal acceleration of the ball in terms of M, T_1, T_2, and any fundamental constants?

(A) $\frac{T_2-T_1}{2M}$

(B) g

(C) $\frac{T_1-T_2}{2M}$

(D) $\frac{T_1+T_2}{2M}$ ✓

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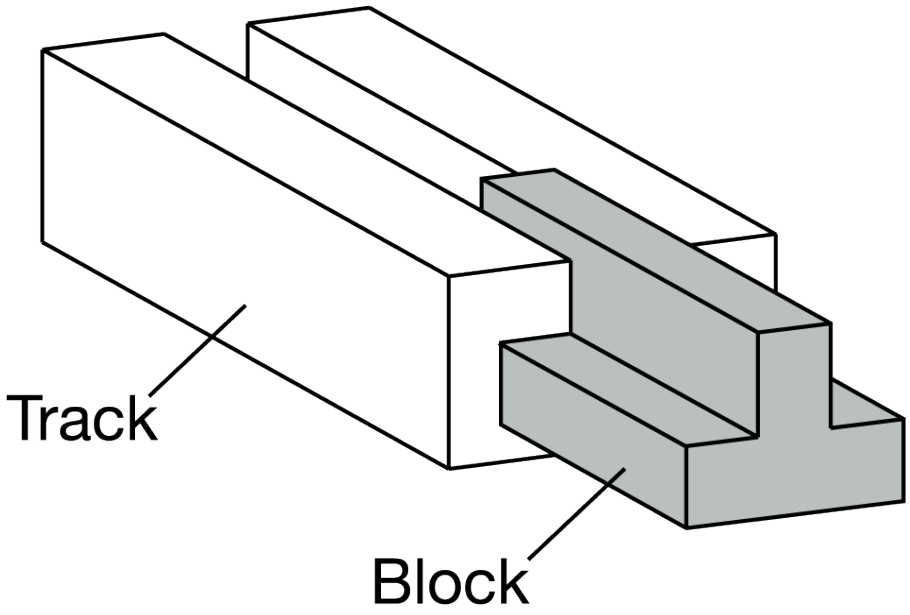
15.



A student must determine the inertial mass of a block attached to a horizontal track. The block is free to move horizontally along the track, as shown above. Frictional forces are considered to be negligible. The student may only choose two measuring tools to determine the inertial mass of the block. What tools should the student choose? Select two answers.

A Stopwatch

B Accelerometer ✓

C Force sensor ✓

D Meterstick

16. A rocket on Earth experiences an upward applied force from its thrusters. As a result of this force, the rocket accelerates upward at $2\ \mathrm{m/s^2}$. Assume that there are no other upward forces exerted on the rocket and that wind resistance is negligible. Which of the following combinations of the rocket's mass m_{Rocket} and force from its thrusters $F_{Thrusters}$ would result in an upward acceleration of $2\ \mathrm{m/s^2}$? Select two answers.

A M_{Rocket} $1\ \mathrm{kg}$ $F_{Thrusters}$ $12\ \mathrm{N}$ ✓

B M_{Rocket} $2\ \mathrm{kg}$ $F_{Thrusters}$ $4\ \mathrm{N}$

C M_{Rocket} $3\ \mathrm{kg}$ $F_{Thrusters}$ $6\ \mathrm{N}$

D M_{Rocket} $3\ \mathrm{kg}$ $F_{Thrusters}$ $36\ \mathrm{N}$ ✓

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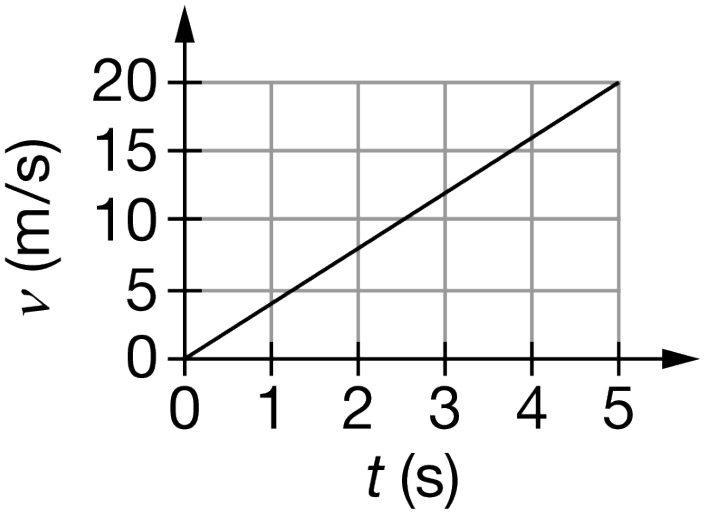
17.



A $2\,\text{kg}$ object is released from rest near the surface of a planet with a negligible atmosphere. A graph of the object's speed v as a function of time t is shown. What is the weight of the object on the planet?

(A) $2\,\text{N}$

(B) $8\,\text{N}$ ✓

(C) $10\,\text{N}$

(D) $20\,\text{N}$

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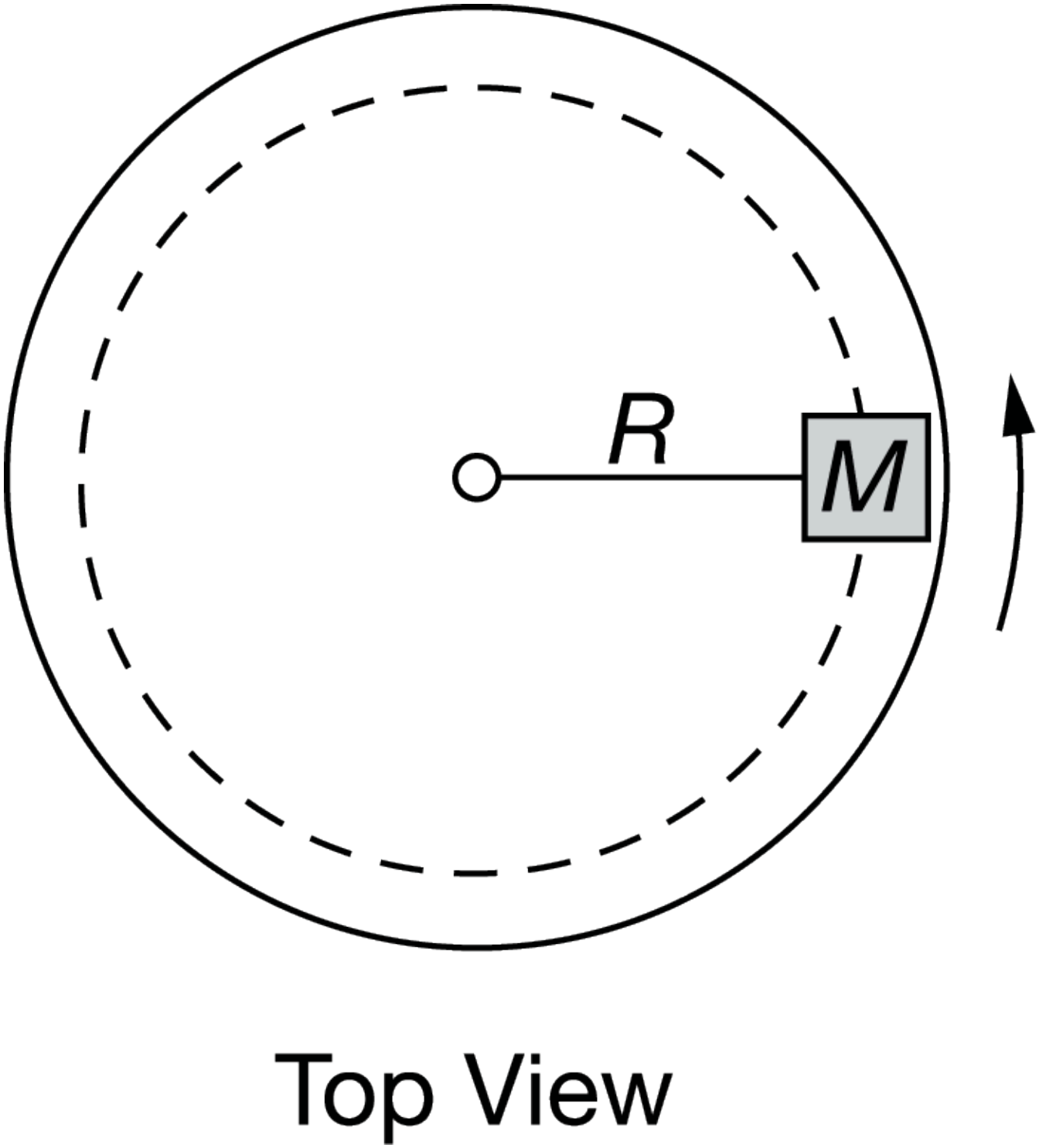
18.



An object of mass M is placed on a disk that can rotate. One end of a string is tied to the object while the other end of the string is held by a pole that is located at the center of the disk. Initially, the object is spun in a horizontal circle of radius R at a constant tangential speed of v_0, as shown in the figure, such that the tension in the string is T . At a later time, the disk is spun such that the tangential speed of the object is increased to $2v_0$. At a later time, the tangential speed of the object is increased to $3v_0$. Which of the following diagrams could represent the forces

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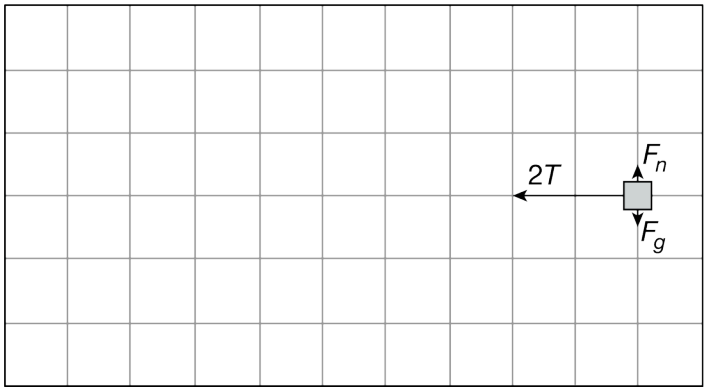
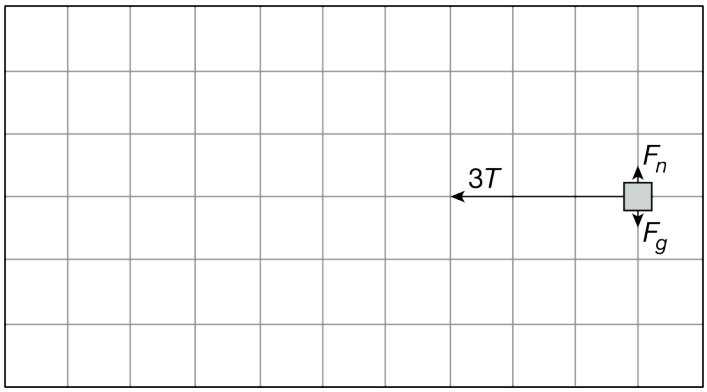
exerted on the object at one of the given speeds? Assume that the force of static friction is negligible. Select two answers.

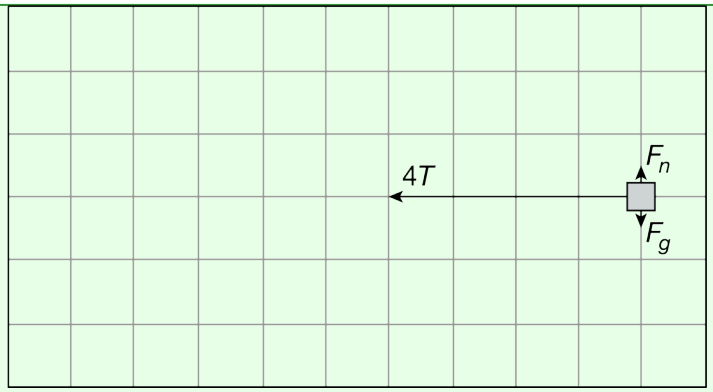
A



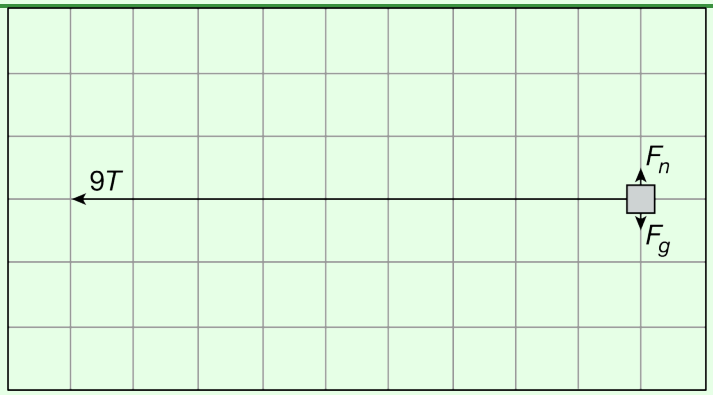
B



C ✓



D ✓



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19. A moon of mass 1×10^{20} kg is in a circular orbit around a planet. The planet exerts a gravitational force of 2×10^{21} N on the moon. The centripetal acceleration of the moon is most nearly

(A) $0.05 \frac{\text{m}}{\text{s}^2}$

(B) $10 \frac{\text{m}}{\text{s}^2}$

(C) $20 \frac{\text{m}}{\text{s}^2}$ ✓

(D) $2 \times 10^{41} \frac{\text{m}}{s^2}$

20. In which of the following situations is the gravitational force the dominant force? Select two answers.

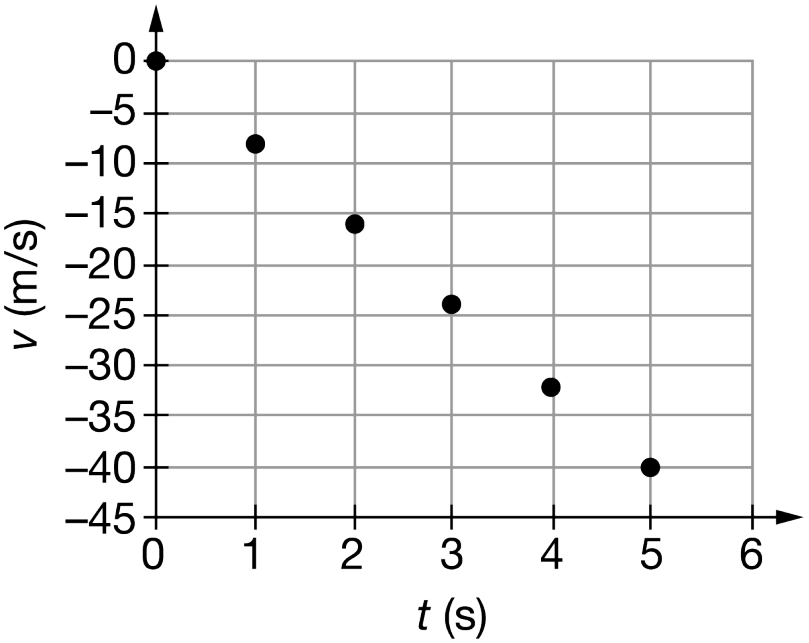
A A satellite is in orbit around a planet. ✓

B An object is in free fall just after it is released from rest. ✓

C An electron and a proton are bound together in an atom.

D A proton and a neutron are bound together in an atom's nucleus.

21.



A student uses a motion sensor to collect data about an object's velocity v as a function of time t after it is released from rest near Earth's surface. The student claims that the graph shown represents the object while in free fall. Does the data from the graph support the student's claim?

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(A) Yes, because the graph shows that the object's speed increases as it falls, which is consistent for an object that is in free fall.

(B) Yes, because the graph shows that the object's velocity is downward as it falls, which is consistent for an object that is in free fall.

(C) No, because the area under the curve of the graph indicates that the acceleration is increasing, which indicates that a force other than gravity is exerted on the object.

(D) No, because the slope of the curve of the graph indicates that the acceleration is less than g, which indicates that a force other than gravity is exerted on the object. ✓

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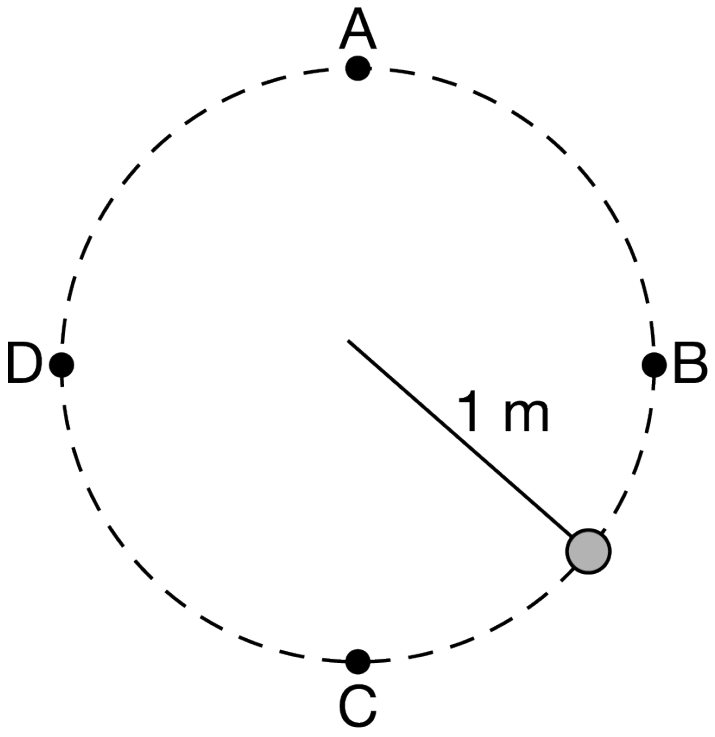
22.



Side View

Position	Tangential Speed (m/s)
A	3.16
B	5.46
C	7.07
D	5.46

Student X ties one end of a string to a 0.5 kg ball and swings the ball in a vertical circle of radius 1 m, as shown in the figure. Student Y uses video analysis to determine the speed of the ball at points A, B, C, and D, as shown in the table. Student X states that the data are incorrect because the tension in the string provides a centripetal force that should cause the ball to travel with a constant tangential speed. Is Student X's reasoning correct, and why or why not?

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(A) Yes, because the tension force from the string is the only force that is directed inward at all points along the ball's circular path.

(B) Yes, because centripetal acceleration of the ball should be constant at all points along the ball's circular path.

(C) No, because a centrifugal force that is directed outward is exerted on the ball at all points along the ball's circular path.

(D) No, because the net centripetal force exerted on the ball is the combination of the tension force from the string and the force due to gravity from Earth. ✓