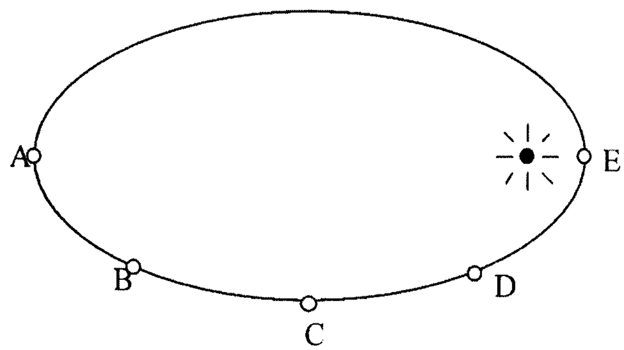
AP Physics – Unit 3 – Circular motion and Gravitational forces

Pre- Exam – FRQ

Question 1 (7 points)

The figure shown represents the path of a planet as it orbits the Sun. The planet follows an elliptical path, but unlike the ellipse followed by a pendulum, the Sun is at a focal point of the ellipse and not at the center of the elliptical path. The planet is moving from point A to point E as shown in the figure.

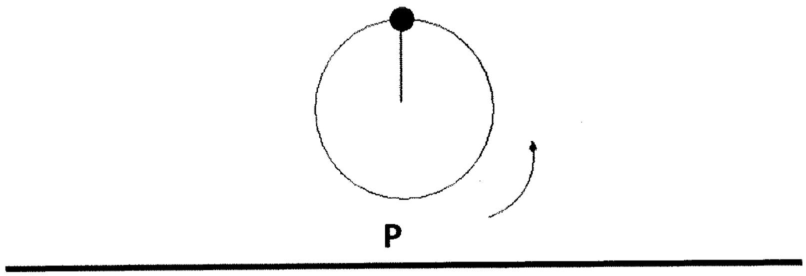


(a) On the figure provided, draw an arrow showing the direction of the net force on the planet at points A, C, and E. If the net force is zero at any point, label the point with 0.

(b) Rank the magnitudes of the gravitational force on the planet at points A, B, C, D, and E. Justify your answer.

(c) Rank the magnitude of the velocities on the planet at points A, C, and E. Describe the motion of the planet from point A to point E. Justify your answer

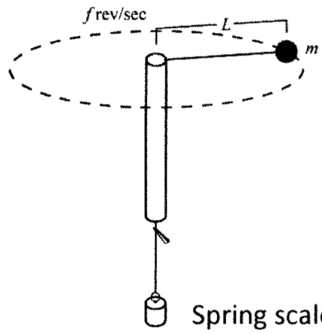
Question 2



A ball of mass M is attached to a string of length L, moves in a circle in a vertical plane as shown above. At the top of the circular path, the tension in the string is twice the weight of the ball. At the bottom, the ball just clears the ground. Air resistance is negligible. Express all answers in terms of M, L, and g. a. Determine the magnitude and direction of the net force on the ball when it is at the top.

a) Draw a force diagram of the ball at the top of circle and at the bottom
b) Determine the speed, v, of the ball at the top
c) Determine the time it takes the ball to reach the ground
d) Determine the horizontal distance the ball travels before hitting the ground

Questions 3



To study circular motion, two students use the hand-held device as shown: This consists of a rod on a spring scale is attached. A polished glass tube attached at the top serves as a guide for a light cord attached to the spring scale. A ball of mass 0.200 kg is attached to the other end of the cord. One student swings the ball around at a constant speed in a horizontal circle with a radius of 0.500 m. Assume friction and air resistance are negligible.

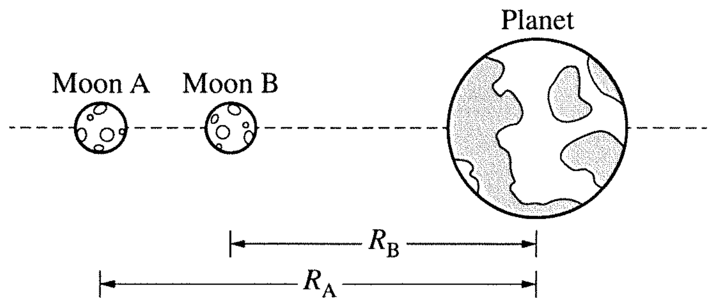
a) Explain how the students, by using a timer and the information given above, can determine the speed of the ball as it is revolving.

b) The speed of the ball is determined to be 3.7 m/s. Assuming that the cord is horizontal as it swings, calculate the expected tension in the cord.

c) The actual tension in the cord is measured by the spring scale to be 5.8 N. What is the percent difference between this measured value of the tension and the value calculated in part c?

d) The student finds that, despite their best efforts, they cannot swing the ball so that the cord remains exactly horizontal.
   i. Draw a free body diagram to represent the forces action on the ball and identify the force that each vector represents.
   ii. Explain why it is not possible for the ball to swing so that the cord remains exactly horizontal
   iii. Calculate the angle that the cord makes with the horizontal.

Question 4

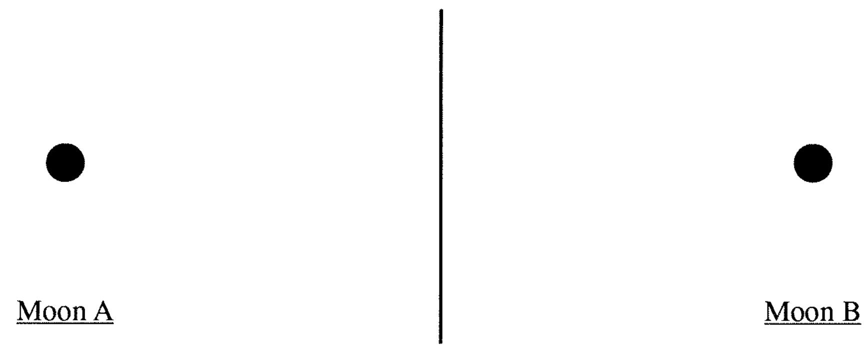


<u>Note:</u> Figure not drawn to scale.

4. (12 points, suggested time 25 minutes)

Two identical moons, Moon A and Moon B, orbit a planet. The mass m_0 of each moon is significant, but less than the mass m_p of the planet. At some point in their orbits, the planet and the two moons are aligned as shown in the figure.

(a) The following dots represent the two moons when they are at the locations shown in the previous figure. On each dot, draw and label the forces (not components) exerted on Moon A and on Moon B. Each force must be represented by a distinct arrow starting on, and pointing away from, the appropriate dot.



(b) Consider the net gravitational force exerted on each moon due to the planet and the other moon.

i. Justify why the magnitude of the net force exerted on Moon A <u>could</u> be larger than the magnitude of the net force exerted on Moon B.

GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 2** on this page.

ii. Justify why the magnitude of the net force exerted on Moon B could be larger than the magnitude of the net force exerted on Moon A.

(c) Derive expressions for both of the following quantities. Express your answers in terms of m_0, m_p, R_A, R_B, and physical constants, as appropriate.

- The net force F_A exerted on Moon A

- The net force F_B exerted on Moon B

GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 2** on this page.

(d)

i. Could the expressions in part (c) support your reasoning in part (b)(i) ?

____ Yes ____ No

Explain your reasoning.

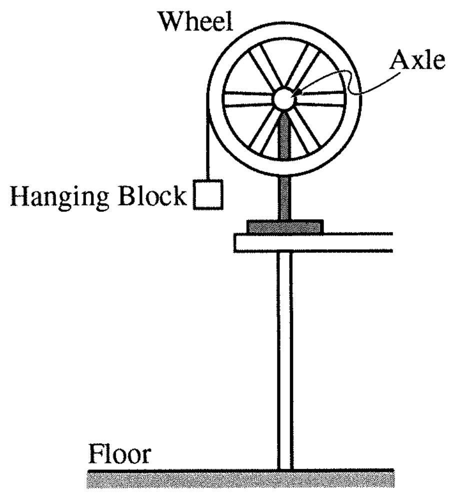
ii. Could the expressions in part (c) support your reasoning in part (b)(ii) ?

____ Yes ____ No

Explain your reasoning.

GO ON TO THE NEXT PAGE.

Begin your response to **QUESTION 3** on this page.



3. (12 points, suggested time 25 minutes)

A wheel is mounted on a horizontal axle. A light string is attached to the wheel's rim and wrapped around it several times, and a small block is attached to the free end of the string, as shown in the figure. When the block is released from rest and begins to fall, the wheel begins to rotate with negligible friction.

Two students are discussing how different forms of energy change as the block falls. One student says that the kinetic energy of the block increases as it falls. The second student says that this is because gravitational potential energy is converted to kinetic energy. The students decide to test whether the decrease in gravitational potential energy is equal to the increase in the block's kinetic energy from when the block starts moving to immediately before it reaches the floor.

GO ON TO THE NEXT PAGE.