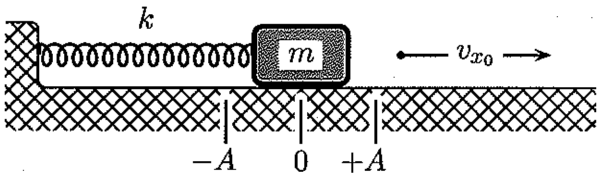
This print-out should have 15 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering. The due time is Central time.

AP M 1993 MC 07 08

13:04, trigonometry, multiple choice, > 1 min, fixed.

001

A block on a horizontal frictionless plane is attached to a spring, as shown below. The block oscillates along the x-axis with simple harmonic motion of amplitude A.



Which statement about the block is correct?

1. At $x = A$, its displacement is at a maximum.

2. At $x = 0$, its velocity is zero.

3. At $x = 0$, its acceleration is at a maximum.

4. At $x = A$, its velocity is at a maximum.

5. At $x = A$, its acceleration is zero.

002

Which statement about energy is correct?

1. The potential energy of the spring is at a minimum at $x = 0$.

2. The potential energy of the spring is at a minimum at $x = A$.

3. The kinetic energy of the block is at a minimum at $x = 0$.

4. The kinetic energy of the block is at a maximum at $x = A$.

5. The kinetic energy of the block is always equal to the potential energy of the spring.

Energy in Oscillations

13:04, trigonometry, multiple choice, > 1 min, normal.

003

A particle oscillates harmonically

$$x = A \sin(\omega t + \phi_0),$$

with amplitude 10 m, angular frequency π s^{-1}, and initial phase $\frac{\pi}{3}$ radians. Every now and then, the particle's kinetic energy and potential energy happen to be equal to each other ($K = U$).

When does this equality happen for the first time after $t = 0$?

1. 0.4167 s

2. 0.8623 s

3. 0.2238 s

4. 0.1294 s

5. 0.5884 s

6. 0.7615 s

7. 0.6547 s

8. 0.5267 s

9. 0.3467 s

10. 0.9967 s

Simple Harmonic Motion 01

13:04, trigonometry, multiple choice, > 1 min, fixed.

004

The displacement in simple harmonic motion is a maximum when

1. acceleration is zero.

2. potential energy is zero.

3. kinetic energy is maximum.

4. the potential energy function has its maximum value per cycle.

AP M 1998 MC 10

13:05, trigonometry, multiple choice, < 1 min, fixed.

005

A pendulum with a period of 1 s on Earth, where the acceleration due to gravity is g, is taken to another planet, where its period is 2 s.

The acceleration due to gravity on the other planet is most nearly

1. $a_g = \dfrac{g}{4}$

2. $a_g = \dfrac{g}{2}$

3. $a_g = g$

4. $a_g = 2\,g$

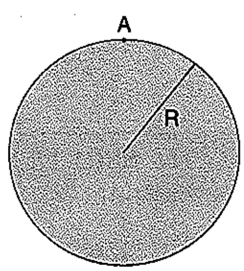
5. $a_g = 4\,g$

Oscillation of a Disk 01

13:06, calculus, multiple choice, > 1 min, fixed.

006

A uniform circular disk is pivoted at its edge A.



Find its period of the small oscillations. Use small angle approximation.

1. $T = 2\pi\sqrt{\dfrac{5\,R}{3\,g}}$

2. $T = 2\pi\sqrt{\dfrac{R}{g}}$

3. $T = 2\pi\sqrt{\dfrac{7\,R}{6\,g}}$

4. $T = 2\pi\sqrt{\dfrac{4\,R}{3\,g}}$

5. $T = 2\pi\sqrt{\dfrac{3\,R}{2\,g}}$

6. $T = 2\pi\sqrt{\dfrac{11\,R}{6\,g}}$

7. $T = 2\pi\sqrt{\dfrac{2\,R}{g}}$

8. $T = 2\pi\sqrt{\dfrac{R}{2\,g}}$

9. $T = 2\pi\sqrt{\dfrac{R}{3\,g}}$

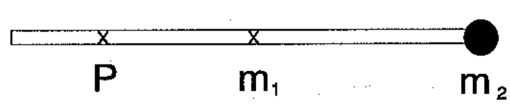
10. $T = 2\pi\sqrt{\dfrac{5\,R}{2\,g}}$

Mass on the End of a Stick

13:06, trigonometry, multiple choice, > 1 min, fixed.

007

Consider a uniform stick with mass m_1 and length l. A mass m_2 is attached to its end. It is pivoted at P which is $\dfrac{1}{4}$-way from the other end.



Given: $m_1 = m$, and $m_2 = \frac{m}{3}$.

Find: The moment of inertia about a rotation axis passing through P perpendicular to the paper.

1. $\frac{1}{12} m\, l^2$
2. $\frac{1}{6} m\, l^2$
3. $\frac{1}{4} m\, l^2$
4. $\frac{1}{3} m\, l^2$
5. $\frac{5}{12} m\, l^2$
6. $\frac{1}{2} m\, l^2$
7. $\frac{7}{12} m\, l^2$
8. $\frac{2}{3} m\, l^2$
9. $\frac{3}{4} m\, l^2$
10. $\frac{5}{6} m\, l^2$

008

The total kinetic energy as the mass-rod system passes the vertical after being released from rest in the horizontal position is given by

1. $\frac{1}{12} m\, l\, g$
2. $\frac{1}{6} m\, l\, g$
3. $\frac{1}{4} m\, l\, g$
4. $\frac{1}{3} m\, l\, g$
5. $\frac{5}{12} m\, l\, g$
6. $\frac{3}{4} m\, l\, g$
7. $\frac{7}{12} m\, l\, g$
8. $\frac{2}{3} m\, l\, g$
9. $\frac{1}{2} m\, l\, g$
10. $\frac{5}{6} m\, l\, g$

009

The period of oscillation for the small angle approximation about the vertical direction is given by: (Denote the period of a simple pendulum with length l to be T_0, where $T_0 = 2\pi\sqrt{\frac{l}{g}}$).

1. $\sqrt{\frac{1}{12}}\, T_0$
2. $\sqrt{\frac{1}{6}}\, T_0$
3. $\frac{1}{2}\, T_0$
4. $\sqrt{\frac{2}{3}}\, T_0$

5. $\sqrt{\frac{5}{12}}\, T_0$

6. $\sqrt{\frac{1}{2}}\, T_0$

7. $\sqrt{\frac{7}{12}}\, T_0$

8. $\sqrt{\frac{1}{3}}\, T_0$

9. $\sqrt{\frac{3}{4}}\, T_0$

10. $\sqrt{\frac{5}{6}}\, T_0$

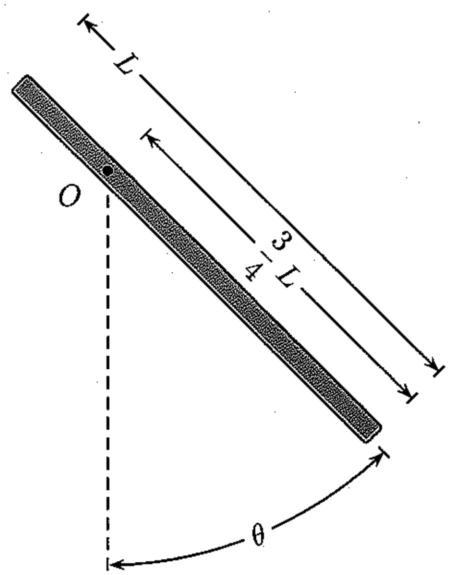
Uniform Rod as a Pendulum 01

13:06, calculus, multiple choice, > 1 min, normal.

010

Hint: The moment of inertia of a uniform rod about its center-of-mass is $\frac{1}{12}\, M\, L^2$.

Consider a uniform rod with a mass m and length L pivoted on a frictionless horizontal bearing at a point O $\left(\frac{3}{4}\, L \text{ from the lower end}\right)$, as shown in the figure.



The moment of inertia I of the rod about the pivot point O is given by

1. $I = \frac{7}{48}\, M\, L^2$

2. $I = \frac{19}{81}\, M\, L^2$

3. $I = \frac{13}{75}\, M\, L^2$

4. $I = \frac{19}{147}\, M\, L^2$

5. $I = \frac{7}{81}\, M\, L^2$

6. $I = \frac{43}{192}\, M\, L^2$

7. $I = \frac{7}{75}\, M\, L^2$

8. $I = \frac{19}{192}\, M\, L^2$

9. $I = \frac{1}{9}\, M\, L^2$

10. $I = \frac{31}{147}\, M\, L^2$

011

Hint: Use the small angle approximation.

If θ is in radians, then Newton's second law for rotational motion for this pendulum is given by

1. $\frac{d^2\,\theta}{dt^2} = -\frac{12}{7}\,\frac{g}{L}\,\theta$

2. $\frac{d^2\theta}{dt^2} = -\frac{21}{26}\frac{g}{L}\theta$

3. $\frac{d^2\theta}{dt^2} = -\frac{24}{19}\frac{g}{L}\theta$

4. $\frac{d^2\theta}{dt^2} = -\frac{45}{26}\frac{g}{L}\theta$

5. $\frac{d^2\theta}{dt^2} = -\frac{9}{14}\frac{g}{L}\theta$

6. $\frac{d^2\theta}{dt^2} = -\frac{63}{38}\frac{g}{L}\theta$

7. $\frac{d^2\theta}{dt^2} = -\frac{105}{62}\frac{g}{L}\theta$

8. $\frac{d^2\theta}{dt^2} = -\frac{72}{43}\frac{g}{L}\theta$

9. $\frac{d^2\theta}{dt^2} = -\frac{15}{14}\frac{g}{L}\theta$

10. $\frac{d^2\theta}{dt^2} = -\frac{3}{2}\frac{g}{L}\theta$

012

Based on the equation of the motion given in the previous question, the period of this pendulum in the small angle approximation is given by

1. $T = 2\pi\sqrt{\frac{7}{12}\frac{L}{g}}$

2. $T = 2\pi\sqrt{\frac{14}{15}\frac{L}{g}}$

3. $T = 2\pi\sqrt{\frac{38}{63}\frac{L}{g}}$

4. $T = 2\pi\sqrt{\frac{2}{3}\frac{L}{g}}$

5. $T = 2\pi\sqrt{\frac{43}{72}\frac{L}{g}}$

6. $T = 2\pi\sqrt{\frac{26}{45}\frac{L}{g}}$

7. $T = 2\pi\sqrt{\frac{62}{105}\frac{L}{g}}$

8. $T = 2\pi\sqrt{\frac{14}{9}\frac{L}{g}}$

9. $T = 2\pi\sqrt{\frac{26}{21}\frac{L}{g}}$

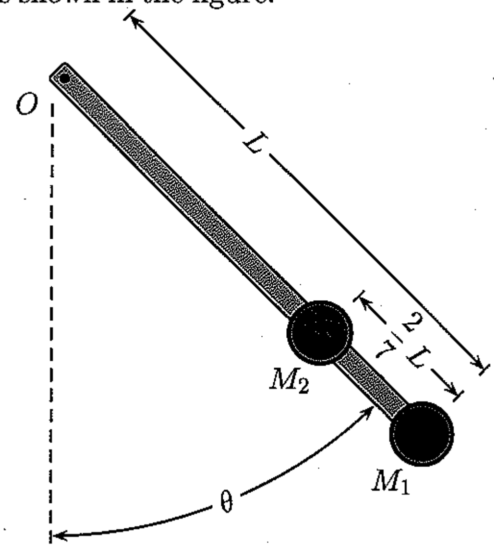
10. $T = 2\pi\sqrt{\frac{19}{24}\frac{L}{g}}$

Masses on a Pendulum 01

13:06, calculus, multiple choice, > 1 min, normal.

013

Consider a light rod of negligible mass and length L pivoted on a frictionless horizontal bearing at a point O. Attached to the end of the rod is a mass M_1. Also, a second mass M_2 of equal size (i.e., $M_1 = M_2 = M$) is attached to the rod $\left(\frac{2}{7}\,L \text{ from the lower end}\right)$, as shown in the figure.



What is the moment of inertia I about O?

1. $I = \frac{74}{49}\,M\,L^2$

2. $I = \frac{58}{49}\,M\,L^2$

3. $I = \frac{53}{49}\,M\,L^2$

4. $I = \frac{65}{49}\,M\,L^2$

5. $I = \frac{34}{25}\,M\,L^2$

6. $I = \frac{26}{25} M L^2$

7. $I = \frac{41}{25} M L^2$

8. $I = \frac{130}{81} M L^2$

9. $I = \frac{25}{16} M L^2$

10. $I = \frac{13}{9} M L^2$

014

If θ is in radians, what is Newton's second law of rotational motion for this pendulum? Use the small angle approximation.

1. $I \frac{d^2\theta}{dt^2} = -\frac{12}{7} M g L \theta$

2. $I \frac{d^2\theta}{dt^2} = -\frac{14}{9} M g L \theta$

3. $I \frac{d^2\theta}{dt^2} = -\frac{5}{3} M g L \theta$

4. $I \frac{d^2\theta}{dt^2} = -\frac{11}{9} M g L \theta$

5. $I \frac{d^2\theta}{dt^2} = -\frac{12}{9} M g L \theta$

6. $I \frac{d^2\theta}{dt^2} = -\frac{5}{4} M g L \theta$

7. $I \frac{d^2\theta}{dt^2} = -\frac{11}{7} M g L \theta$

8. $I \frac{d^2\theta}{dt^2} = -\frac{7}{5} M g L \theta$

9. $I \frac{d^2\theta}{dt^2} = -\frac{10}{7} M g L \theta$

10. $I \frac{d^2\theta}{dt^2} = -\frac{6}{5} M g L \theta$

015

Based on the equation of the motion given in the previous question, what is the period of this pendulum in the small angle approximation?

1. $T = 2\pi \sqrt{\frac{37}{42} \frac{L}{g}}$

2. $T = 2\pi \sqrt{\frac{85}{99} \frac{L}{g}}$

3. $T = 2\pi \sqrt{\frac{29}{35} \frac{L}{g}}$

4. $T = 2\pi \sqrt{\frac{5}{6} \frac{L}{g}}$

5. $T = 2\pi \sqrt{\frac{13}{15} \frac{L}{g}}$

6. $T = 2\pi \sqrt{\frac{53}{63} \frac{L}{g}}$

7. $T = 2\pi \sqrt{\frac{65}{72} \frac{L}{g}}$

8. $T = 2\pi \sqrt{\frac{17}{20} \frac{L}{g}}$

9. $T = 2\pi \sqrt{\frac{89}{104} \frac{L}{g}}$

10. $T = 2\pi \sqrt{\frac{41}{45} \frac{L}{g}}$