Use g=10m/s^2. Ignore drag and use standard MKS units unless indicated otherwise.

1. Uniform sphere X with mass 1kg and radius 1m is dropped from rest in a vacuum near Earth's surface and free falls 5m. How many more seconds would it take to fall a total of 20m?

   A. 1 B. 2 C. 3 D. 4 E. NOTA

2. Uniform sphere X with mass 1kg and radius 1m is dropped from rest in a vacuum near Earth's surface and free falls 5m. To the nearest 1J what is the net work done on the sphere?

   A. 0 B. 5 C. 25 D. 50 E. NOTA

3. Uniform sphere X with mass 1kg and radius 1m is released from rest in a vacuum near Earth's surface and rolls 10m, no slipping, down a long incline that meets the horizon at a 30^o angle. In $kg \cdot m^2/s$, what is the final angular momentum of the sphere about an axis through its center?

   A. 10 B. $\frac{4\sqrt{15}}{3}$ C. $\frac{4\sqrt{35}}{7}$ D. $2\sqrt{10}$ E. NOTA

4. Uniform sphere X with mass 1kg and radius 1m is released from rest in a vacuum near Earth's surface and rolls 10m without slipping down a long incline that makes a 30^o angle with the horizon. What is the magnitude of the force of friction on the sphere in Newtons?

   A. $10\sqrt{3}$ B. $5\sqrt{3}$ C. $\frac{10}{7}$ D. 0 E. NOTA

5. Uniform sphere X with mass 1kg and radius 1m is released from rest in a vacuum near Earth's surface and rolls 10m without slipping down a long incline that makes a 30^o angle with the horizon. What is the energy dissipated due to friction in Joules?

   A. $50\sqrt{3}$ B. 25 C. $25\sqrt{3}$ D. 0 E. NOTA

6. A 4kg box rests on top of a table with a frictionless top. The 4kg box is attached to an ideal string which runs over an ideal pulley mounted on the edge of the table and is attached at the other end to the top of a 1kg uniform solid sphere which is held at rest with its bottom 8m above the ground. The table is held fixed to the ground with bolts. When the sphere is released how many seconds will it take for it to touch the ground?

A. $\frac{2\sqrt{10}}{5}$ B. $\frac{4\sqrt{10}}{25}$ C. 2 D. $2\sqrt{2}$ E. NOTA

7. A 4kg box rests on top of a table with a frictionless top. The 4kg box is attached to an ideal string which runs over an ideal pulley mounted on the edge of the table and is attached at the other end to the top of a 1kg uniform solid sphere which is held at rest with its bottom 8m above the ground. The table is held fixed to the ground with bolts. When the sphere is released what is the tension in the string in Newtons?

A. 2 B. 8 C. 10 D. 12 E. NOTA

8. A 4kg box rests on top of a table with a frictionless top. The 4kg box is attached to an ideal string which runs over an ideal pulley mounted on the edge of the table and is attached at the other end to the top of a 1kg uniform solid sphere which is held at rest with its bottom 8m above the ground. The table is held fixed to the ground with bolts. What is the speed of the sphere (in m/s) just as it reaches the ground?

A. $4\sqrt{10}$ B. $4\sqrt{5}$ C. $4\sqrt{2}$ D. 4 E. NOTA

9. A 4kg box rests on top of a table and the coefficients of friction at their interface are 0.5. The 4kg box is attached to an ideal string which runs over an ideal pulley mounted on the edge of the table and is attached at the other end to the top of a 1kg uniform solid sphere which is held at rest with its bottom 8m above the ground. The table is free to move horizontally. How is the acceleration of the sphere upon release different from if the table were bolted down and the box had no friction?

A. It is greater B. It is less C. It is equal D. Can't tell E. NOTA

10. A 4kg box rests on top of a table with a frictionless top. The 4kg box is attached to an ideal string which runs over an ideal pulley mounted on the edge of the table and is attached at the other end to the top of a 1kg uniform solid sphere which is held at rest with its bottom 8m above the ground. The table is 5kg and is free to slide on the ground. How is the acceleration of the sphere different from if the table were bolted down? Ignore drag.

A. It is greater B. It is less C. It is equal D. Can't tell E. NOTA

11. Based on Kepler's laws by what factor is the period of an orbit multiplied if the semi major axis is multiplied by 4?

A. 2 B. 4 C. 8 D. 16 E. NOTA

12. Based on Newton's laws by what factor must orbital speed be multiplied in order to maintain a circular orbit at double a satellite's present distance from the center of the earth?

A. $\frac{\sqrt{2}}{2}$ B. 1 C. $\sqrt{2}$ D. $2\sqrt{2}$ E. NOTA

13. What would be the magnitude of the acceleration (in m/s^2) of a ball of mass 1kg if a force is applied to the ball that is equivalent to its weight on Earth in the absence of any other forces?

A. 1 B. 2 C. 5 D. 10 E. NOTA

14. Box A has mass 1.5kg. Box B has mass 0.5kg. Box A has initial velocity 4m/s pointed from its center to the center of Box B. Box B is initially at rest. They meet head on in a 1-dimensional collision. Given that they stick together, what will be the momentum of Box B after the collision in $kg \cdot m/s$?

A. 2 B. 1.5 C. 1 D. 0.5 E. NOTA

15. Some payload is dropped from a plane flying horizontally with ground speed 50 m/s over level terrain. The moment the payload is released the plane begins to accelerate 1 m/s^2 in the same direction as its velocity. The payload takes 10.0s to reach the ground. At the moment the payload reaches the ground, which of the following is the closest to the horizontal distance (in meters) between the payload and the plane that dropped it?

A. 50 B. 400 C. 450 D. 500 E. 550

16. An arrow is aimed directly at a toy monkey 50m away from an archer and approximately 37^o above the horizontal. If the archer is at the origin then the monkey is at (40, 30). The arrow is fired 50 m/s at the monkey at exactly the moment the monkey drops from its perch. Ignoring air resistance, by how much does the arrow miss the monkey?

A. 7.2m high B. 0m (hit) C. 7.2m low D. 12.8m high E. NOTA

17. A uniform ladder leans against a frictionless wall. The ladder is 4m long and has a mass of 3kg. What is the minimum value for the coefficient of static friction between the ladder and the floor which would allow the ladder to remain at rest without slipping with an angle of 45^o to the horizon?

A. $2\sqrt{2}$ B. $\sqrt{2}$ C. $\frac{\sqrt{2}}{2}$ D. $\frac{1}{2}$ E. NOTA

18. A stone is dropped from height h and reaches the ground with speed v. At what height is it moving with speed v/2?

A. $\frac{h}{4}$ B. $\frac{h}{2}$ C. $\frac{2h}{3}$ D. $\frac{3h}{4}$ E. NOTA

19. A 9V battery, a 3Ω resistor and an initially uncharged 1F capacitor are connected in series. Which of the following is the closest to the current (in A) through the resistor when the capacitor is at half of the maximum charge?

A. 0.5 B. 1.0 C. 1.5 D. 2.0 E. 3.0

20. How much heat (in J) would it take to increase the pressure of a $.01m^3$ sample of an ideal monatomic gas by 1,000 Pa in a rigid container?

A. 50 B. 25 C. 15 D. 10 E. NOTA

21. Which of the following is closest to the efficiency of a heat engine if 250J of work are done for each 500J of heat exhaust?

A. 25% B. 33% C. 50% D. 67% E. 75%

22. Satellite A and Satellite B orbit the earth in circular orbits. The ratio of the area of the circle of the orbit of A to B is 4. Which of the following is closest to the ratio of the amount of time it takes A to complete a cycle to B?

A. 2 B. $2\sqrt{2}$ C. 4 D. $4\sqrt{2}$ E. 8

23. Will and Bryan are running a race around a track. Bryan starts running before Will, and Bryan runs at a constant speed v. Will begins to run at the moment Bryan finishes his first lap. At what constant speed must Will run so they both finish 4 laps at the same time?

A. $3v$ B. $\frac{3v}{2}$ C. $\frac{4v}{3}$ D. v E. NOTA

24. An object is thrown straight down with an initial velocity of 12m/s from the top of a ladder that is 17m tall. Which of the following is the closest to the time (in s) it takes for the object to hit the ground?

A. 0.6 B. 1.0 C. 1.4 D. 1.8 E. 2.2

25. By what factor will the period be multiplied on an ideal mass spring oscillator if the mass is replaced with one three times as massive?

A. $\frac{\sqrt{3}}{3}$ B. 1 C. $\sqrt{3}$ D. 3 E. NOTA

26. One end of an ideal spring has mass 2M attached and is held fixed. The other end has mass M attached and is initially free to oscillate vertically with period T_1. Then the end with mass 2M is released and the system is allowed to free fall. Assume it continues to oscillate, but with period T_2. Which of the following is the closest to T_2/T_1?

A. $\sqrt{\frac{1}{3}}$ B. $\sqrt{\frac{2}{3}}$ C. 1 D. $\sqrt{3}$ E. NOTA

27. Take α Cen to be a point 4.5 light years from earth as measured from earth. Now suppose ship A leaves Earth traveling at a constant 0.6c headed for α Cen. Which of the following is closest to the number of years it would take to reach α Cen, as measured by a clock on the ship?

A. 4.5 B. 6 C. 7.5 D. 9 E. 10.5

28. Take α Cen to be a point 4.5 light years from earth as measured from earth. Now suppose ship A leaves Earth traveling at a constant 0.8c headed for α Cen. Which of the following is closest to the number of years it would take to reach α Cen, as measured by a clock on earth?

A. 3.5 B. 4.5 C. 5.5 D. 6.5 E. 7.5

29. Take α Cen to be a point 4.5 light years from earth as measured from earth. Now suppose a ship leaves Earth traveling at a constant speed headed for α Cen. At what speed would a clock on the ship measure the travel time to be 4.5 years?

A. $\frac{1}{2}c$ B. $\frac{\sqrt{2}}{2}c$ C. $\frac{\sqrt{3}}{2}c$ D. c E. NOTA

30. Take α Cen to be a point 4.5 light years from earth as measured from earth. Now suppose ship A leaves Earth traveling at a constant 0.6c headed for α Cen and ship B leaves Earth at the same time traveling at a constant 0.8c headed in the opposite direction. Which of the following is closest to the distance between the ships (in lightyears) when ship A arrives at α Cen as measured by an observer on Ship A?

A. 5.7 B. 6.9 C. 8.1 D. 9.3 E. 10.5