Alpha

Math in Physics

Test #123

Directions:

1. Fill out the top left section of the scantron. Do not abbreviate your school name.

2. In the Student ID Number grid, write your 9-digit ID# and bubble.

3. In the Test Code grid, write the 3-digit test# on this test cover and bubble.

4. Scoring for this test is 5 times the number correct plus the number omitted.

5. TURN OFF ALL CELL PHONES.

6. No calculators may be used on this test.

7. Any inappropriate behavior or any form of cheating will lead to a ban of the student and/or school from future National Conventions, disqualification of the student and/or school from this Convention, at the discretion of the Mu Alpha Theta Governing Council.

8. If a student believes a test item is defective, select "E) NOTA" and file a dispute explaining why.

9. If an answer choice is incomplete, it is considered incorrect. For example, if an equation has three solutions, an answer choice containing only two of those solutions is incorrect.

10. If a problem has wording like "which of the following could be" or "what is one solution of", an answer choice providing one of the possibilities is considered to be correct. Do not select "E) NOTA" in that instance.

11. If a problem has multiple equivalent answers, any of those answers will be counted as correct, even if one answer choice is in a simpler format than another. Do not select "E) NOTA" in that instance.

12. Unless a question asks for an approximation or a rounded answer, give the exact answer.

Assume g=10m/s^2 unless specified otherwise.

1. A ball with mass *m* projected horizontally off the end of a table with an initial speed *V*. At a time *t* after it leaves the end of the table it has twice the kinetic energy. What is *t*? Neglect air resistance.

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

2. A ball with mass 2kg is dropped from a height of 20m above a square steel plate. If its elastic collision with the ground takes 2ms, then which of these is a good approximation for the magnitude of the average force delivered by the ball to the plate on the time interval from when the ball was released until it returns to its original position?

   A. 40N B. 20N C. 20,000N D. 40,000N E. NOTA

3. A uniform disk starts from rest on the y-axis at $(0, 1)$ and rolls without slipping down an incline of length $\sqrt{5}$ which meets the x-axis at $(2, 0)$. The disk then continues across a smooth horizontal surface of length 1 and up a long frictionless 45° incline. What is the maximum product of its coordinates?

   A. 3 B. 4 C. 22/9 D. 16/3 E. NOTA

4. A block of mass 2kg starts from rest on the ground and is given an impulse of 100Ns at an angle 15^o above the horizon. Given the path of the block is over flat ground, then what is its horizontal displacement from where it was launched to where it next touches the ground? Ignore drag.

   A. 12.5m B. 250m C. 5m D. 125m E. NOTA

5. Taking the earth to be a uniform sphere with radius 6,400km, then what would be the magnitude of the gravitational field due to earth experienced by a satellite at a location 3,200km above the surface?

   A. 40/9 N/kg B. 60/9 m/s^2 C. 0 N/kg D. 10 m/s^2 E. NOTA

6. For the same earth described in the previous question what would be the gravitational field at a location with half of the distance to the center as defined in Newton's Universal Law of Gravitation?

   A. 160/9 N/kg B. 240/9 m/s^2 C. 0 N/kg D. 7.5 m/s^2 E. NOTA

7. Two boxes are sliding on a head on collision course toward one another across a frictionless surface. The first box has mass 1kg and speed 3 m/s. The second box has mass 2kg and speed 1m/s. If no kinetic energy is lost in their subsequent collision, then what will be the speed of the 1kg box after the collision?

A. 16/3 m/s B. 0 m/s C. 7/3 m/s D. 25/3 m/s E. NOTA

8. For the two boxes in the previous questions; what would have been the speed of the 1kg box if the collision had been perfectly inelastic?

A. 1/3 m/s B. 0 m/s C. 16/3 m/s D. 5/3 m/s E. NOTA

9. What is the change in mechanical energy for a 1kg solid sphere rolling down an incline of 30^o and length 2m when the coefficients of friction between the ball and the incline are 0.5?

A. 10 J B. $\frac{20}{7}$ J C. $5\sqrt{7}$ J D. $\frac{\sqrt{7}}{10}$ J E. NOTA

10. Given a solid uniform sphere with mass 1kg and radius 2m is rotating such that it completes 1 revolution every minute, then how long (in seconds) would it take to complete a revolution if it is compressed into a sphere with radius 1m in the absence of an external torque?

A. 30 B. 15 C. 7.5 D. 60 E. NOTA

11. What is the period of oscillation (in seconds) for a simple pendulum of length 10m?

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

12. Two vertical massless springs are connected end to end such that they will have the same tension. It is also known that the top spring has $k_{top} = \frac{120N}{m}$ and the bottom spring has $k_{bot} = 180N/m$. What would be the amplitude of the oscillation of a 144 g brass cylinder connected to the lower end of the bottom spring? Assume both springs start in their equilibrium state.

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

13. According to Newton's laws what magnitude of gravitational force does a 2kg steel ball exert on the earth when held at rest on the surface?

A. 0 N B. 2 N C. 20 N D. 40 N E. NOTA

14. If person A pulls on one end of a taught massless rope with 100N of force and person B pulls the opposite direction on the other end then what is the tension in the rope?

A. 0 N B. 50N C. 100 N D. 200 N E. NOTA

15. A cannon is on the ground pointing straight up and another cannon is on a 150m building pointed straight down towards the first cannon. The first cannon fires a ball at 100 m/s while the second cannon fires a ball at 50 m/s at the same time. At what height above the first cannon do these shots meet? Ignore Drag.

A. 75 m B. 55 m C. 100 m D. 95 m E. NOTA

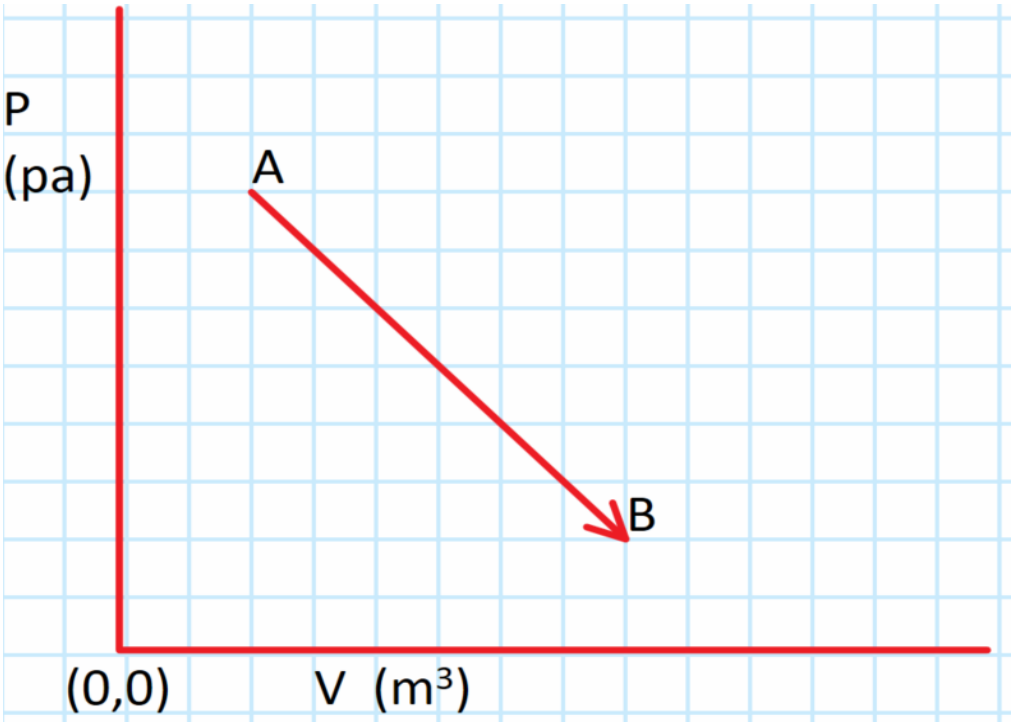
16. A tank of water is filled 1.25 m deep. A small hole is poked in the side near the bottom. With what speed does the water exit the hole? Ignore viscosity.

A. 5 m/s B. 6.125 m/s C. 12.5 m/s D. 10 m/s E. NOTA

17. Vector A has magnitude 5 and is pointed $53°$ above the positive x-axis and vector B has magnitude 10 and is pointed $37°$ below the negative x axis. What is the approximate y-component of their sum?

A. 2 B. -2 C. 5 D. -5 E. NOTA

Use this PV diagram of an enclosed ideal monatomic gas in contact with a piston for questions 18-20



18. What is the work done on the gas as it goes from state A (80,000 pa, .2 m^3) to state B (20,000 pa, .8 m^3)?

A. 0 kJ B. -18 kJ C. -30 kJ D. 30 kJ E. NOTA

19. If the temperature of the gas in state A measured in Kelvin is T_1=300, and the temperature in state B in Celsius is T_2 then which of these is closest to $T_1 - T_2$?

A. $5(T_1+273)$ B. $5(T_1-273)$ C. 273 D. -273 E. NOTA

20. If state C is the midpoint between states A and B and if the temperature of the gas in state C is T_3 then what is the max theoretical efficiency of an engine operating between reservoirs at the temperatures T_1 and T_3?

A. 56% B. 64% C. 36% D. 24% E. NOTA

21. If a new planet has twice the density of Earth but only 2/5 of the radius then which of these is the closest to the surface gravitational field of the new planet?

A. 4 m/s^2 B. 3.2 m/s^2 C. 8 m/s^2 D. 62.5 m/s^2 E. NOTA

22. If a planet in an elliptical orbit around a star is moving 29.25 km/s at the point closest to the star and 13 km/s at the point farthest away then how fast will it move when it is at the point in its orbit closest to the center of its orbit?

A. $13\sqrt{2}$ km/s B. $10\sqrt{6}$ km/s C. 19.5 km/s D. 25 km/s E. NOTA

23. Capacitors X, Y, and Z with capacitances $C_X, C_Y,$ and C_Z respectively with $C_Y = 2C_X$ and $C_Z = 3C_X$. If they are in a circuit so that X and Y are parallel to each other while they are in series with Z and C_{eq} is the equivalent capacitance of the three, then what is C_{eq}/C_X?

A. 1 B. 6 C. 4 D. 5/6 E. NOTA

24. If an interference pattern is produced with laser light through a double slit with 1st and 2nd order fringe separation y, then what would be the new separation if the energy per photon were doubled?

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

25. What frequency is perceived by an observer moving at Mach 0.2 toward a speaker moving at Mach 0.2 towards the observer if the speaker emits a sound of frequency 50Hz?

A. 33⅓ Hz B. 70 Hz C. 50 Hz D. 75 Hz E. NOTA

26. Four identical beams of light are fired through the same atmosphere into 4 different solid prisms. Each incident ray is 45º. The refracted rays are measured and have the following angles to the normal of the boundary: Ray 1 is 40º, Ray 2 is 35º, Ray 3 is 50º, Ray 4 is 55º. Which ray is traveling fastest after the refraction?

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

27. What is the magnification of an image formed by a converging mirror with radius of curvature 20 cm if it is placed 5 cm from an object?

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

28. If a diverging lens with a focal length of 20 cm is placed 10 cm away from a candle then how far will the image of the candle be from the candle?

A. 3⅓ cm B. 6⅔ cm C. 10 cm D. 13⅓ cm E. NOTA

29. Two 2kg blocks are stacked one top of another and at rest on a table. If the coefficients of friction for all surfaces are 2 then what is the maximum force that can be applied to the bottom block without the top block slipping?

A. 40N B. 160N C. 80N D. 120N E. NOTA

30. A 10kg box is moving 30 m/s up a rough incline, which makes an angle of 45° with the horizon. The coefficient of friction between the box and the slope is 1. How far will the box move along the incline before ever coming to rest?

A. $\frac{30}{10\sqrt{2}-5}$ B. $\frac{30}{10\sqrt{2}}$ C. 6 D. 10 E. NOTA