AP PHYSICS 1 & C: DYNAMICS
(Classes 1 & 2)

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and place the letter of your choice in the corresponding box on the student answer sheet.

Note: To simplify calculations, you may use $g = 10\,\mathrm{m/s^2}$ in all problems.

1. Which of the following involves a net force?

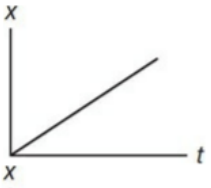
   I. A ball on the end of a string travels in circular motion.
   II. A space probe travels with a constant velocity in a straight line between planets.
   III. An object has a constant horizontal velocity, but a decreasing vertical velocity.

   (A) I only
   (B) I and II only
   (C) II and III only
   (D) I and III only
   (E) I, II, and III

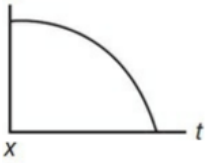
2. A small moving block collides with a large block at rest. Which of the following is true of the forces the blocks apply to each other

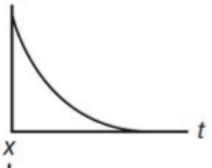
   (A) The small block exerts twice the force on the large block compared to the force the large block exerts on the small block.
   (B) The small block exerts half the force on the large block compared to the force the large block exerts on the small block.
   (C) The small block exerts exactly the same amount of force on the large block that the large block exerts on the small block.
   (D) The large block exerts a force on the small block, but the small block does not exert a force on the large block.
   (E) The small block exerts a force on the large block, but the large block does not exert a force on the small block.

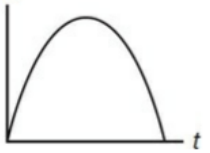
3. Which of the following position vs. time graphs shows an example of the law of inertia?

   (A) 

   (B) 

   (D) 

   (D) 

   (E) 

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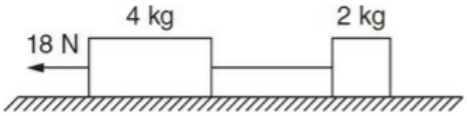
Questions 4-5

Two blocks, 4.0 kg and 2.0 kg, are connected by a string. An applied force F of magnitude 18 N pulls the blocks to the left.



4. The acceleration of the SI4. block is

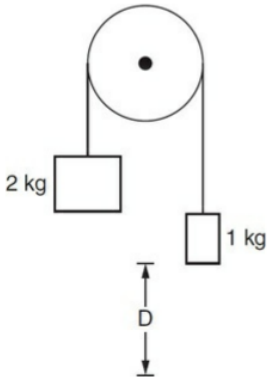
(A) 2.0 m/s^2
(B) 3.0 m/s^2
(C) 4.0 m/s^2
(D) 4.5 m/s^2
(E) 6.0 m/s^2

5. The tension in the string between the blocks is

(A) 4.0 N
(B) 6.0 N
(C) 12 N
(D) 16 N
(E) 18 N

Questions 6-7

A system consists of two blocks having masses of 2.0 kg and 1.0 kg. The blocks are connected by a string of negligible mass and hung over a light pulley, and then released from rest.



6. The acceleration of the 2.0 kg block is most nearly

(A) $\frac{2}{9}g$
(B) $\frac{1}{3}g$
(C) $\frac{1}{2}g$
(D) $\frac{2}{3}g$
(E) g

7. The speed of the 2.0 kg block after it has descended a distance D is most nearly

(A) $\sqrt{\frac{4D}{3}}$
(B) $\sqrt{\frac{2D}{3}}$
(C) $\sqrt{\frac{D}{3}}$
(D) $\sqrt{\frac{D}{2}}$
(E) $\sqrt{\frac{4D}{6}}$

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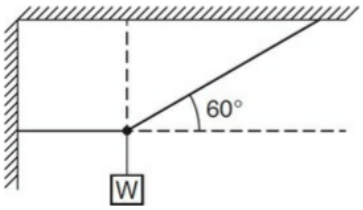
Questions 8-9

A weight of magnitude W is suspended in equilibrium by two cords, one horizontal and one slanted at an angle of 60° from the horizontal, as shown.



8. Which of the following statements is true?
   (A) The tension in the horizontal cord must be greater than the tension in the slanted cord.
   (B) The tension in the slanted cord must be greater than the tension in the horizontal cord.
   (C) The tension is the same in both cords.
   (D) The tension in the horizontal cord equals the weight W.
   (E) The tension in the slanted cord equals the weight W.

9. The tension in the horizontal cord is
   (A) equal to the tension in the slanted cord
   (B) one-third as much as the tension in the slanted cord
   (C) one-half as much as the tension in the slanted cord
   (D) twice as much as the tension in the slanted cord
   (E) three times as much as the tension in the slanted cord

Questions 10-11

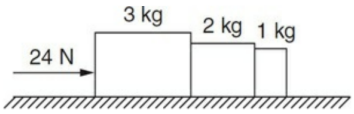
An object of mass m moves along a straight line with a speed described by the equation $v = c + bt^3$.

10. The initial velocity of the mass is
    (A) c
    (B) $ct + bt^3$
    (C) $ct + bt^4$
    (D) bt^2
    (E) bt

11. The net force acting on the mass at time T is
    (A) $3mbT$
    (B) $3mbT^2$
    (C) $3mbT^3$
    (D) $mc + 2mbT^2$
    (E) $mc^2 + 4mbT^4$

12. A wooden block slides down a frictionless inclined plane a distance of 1 meter along the plane during the first second. The distance traveled along the plane by the block during the time between 1 s and 2 s is
    (A) 2 m
    (B) 3 m
    (C) 4 m
    (D) 6 m
    (E) 8 m

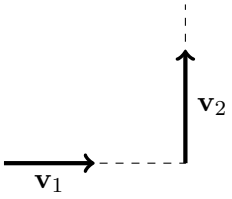
Questions 13-14
Three blocks of mass 3 kg, 2 kg, and 1 kg are pushed along a horizontal frictionless plane by a force of 24 N to the right, as shown.



13. The acceleration of the 2 kg block is
    (A) 144 m/s^2
    (B) 72 m/s^2
    (C) 12 m/s^2
    (D) 6 m/s^2
    (E) 4 m/s^2

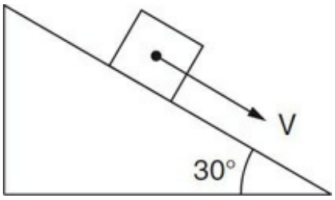
14. The force that the 2 kg block exerts on the 1 kg block is
    (A) 2 N
    (B) 4 N
    (C) 6 N
    (D) 24 N
    (E) 144 N

15. A hockey puck slides along horizontal ice with a velocity $\mathbf{v}_1$ when it is struck by a hockey stick, changing its direction, as shown. After the puck is struck, it has a velocity $\mathbf{v}_2$, which is greater than $\mathbf{v}_1$. Which of the following vectors best represents the direction the force of the hockey stick acted on the puck?



    (A) ↑
    (B) ←
    (C) →
    (D) ↖
    (E) ↗

16. A block of mass 4 kg slides down a rough incline with a constant speed. The angle the incline makes with the horizontal is 30°. The coefficient of friction acting between the block and incline is most nearly



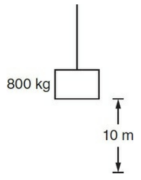
    (A) 0.1
    (B) 0.2
    (C) 0.3
    (D) 0.4
    (E) 0.6

17. An object of mass 3 kg moves along a straight line on the y-axis according to the equation $y = 8t - 4t^2 + t^3$, where y is in meters and t is in seconds. The net force acting on the mass is zero at a time of
    (A) 3/4 s
    (B) 4/3 s
    (C) 8/3 s
    (D) 2 s
    (E) 4 s

18. A ball is thrown straight up into the air, encountering air resistance as it rises. What forces, if any, act on the ball as it rises?
    (A) A decreasing gravitational force and an increasing force of air resistance
    (B) An increasing gravitational force and an increasing force of air resistance
    (C) A decreasing gravitational force and a decreasing force of air resistance
    (D) A constant gravitational force and an increasing force of air resistance
    (E) A constant gravitational force and a decreasing force of air resistance

Questions 19-20

An 800 kg elevator is supported by a vertical cable.



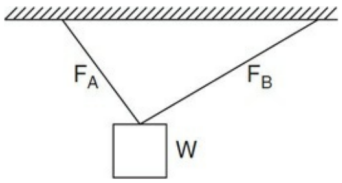
19. The cable has a tension of 10,000 N as it accelerates the elevator upward from rest to a height of 10 m. The acceleration of the elevator is most nearly

(A) 1.0 m/s^2
(B) 2.0 m/s^2
(C) 2.5 m/s^2
(D) 3.5 m/s^2
(E) 4.0 m/s^2

20. The elevator passes the 10 m height on the way up, stops, then begins its descent downward, having an initial velocity as it passes the 10 m height on the way down. If the tension in the cable is now 6000 N, and it comes to rest just before reaching the ground, the initial velocity at the 10 m height must have been most nearly

(A) 5.0 m/s
(B) 7.0 m/s
(C) 29.5 m/s
(D) 12.5 m/s
(E) 16.0 m/s

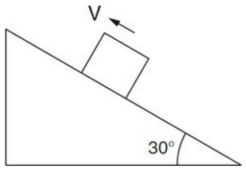
21. A weight W is hung from two threads, A and B, as shown below. The magnitudes of the tensions in each string are F_A and F_B, respectively. Which of the following describes the relationship between F_A, F_B, and W?



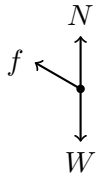
(A) $F_A = F_B = W$
(B) $F_A = F_B$
(C) $F_A < F_B$
(D) $F_A < F_B$
(E) $F_A + F_B = W$

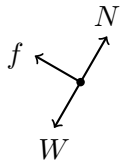
Questions 22-23

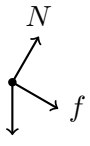
A 1 kg block is sliding up a rough 30° incline and is slowing down with an acceleration of −6 m/s^2. The mass has a weight $\mathbf{W}$, and encounters a frictional force $\mathbf{f}$ and a normal force $\mathbf{N}$.

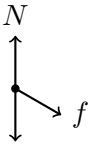


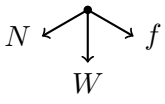
22. Which of the following free body diagrams best represents the forces acting on the block as it slides up the plane?

(A) 

(B) 

(C) 

(D) 

(E) 

23. The magnitude of the frictional force f between the block and the plane is most nearly

(A) 1 N
(B) 2 N
(C) 3 N
(D) 4 N
(E) 5 N

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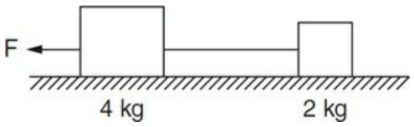
24. A force gives an 8 kg mass an acceleration of 3 m/s^2. The same force will give a 12 kg mass an acceleration of

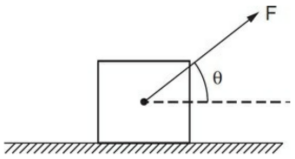
(A) 1 m/s^2
(B) 2 m/s^2
(C) 3 m/s^2
(D) 4 m/s^2
(E) 6 m/s^2

25. Two blocks are pulled by a force of magnitude F along a level surface with negligible friction as shown. The tension in the string between the blocks is



(A) $\frac{1}{4}F$
(B) $\frac{1}{2}F$
(C) $\frac{1}{3}F$
(D) F
(E) $2F$

26. A force of magnitude F pulls up at an angle θ to the horizontal on a block of mass m. The mass remains in contact with the level floor and the coefficient of friction between the block and the floor is μ. The frictional force between the floor and the block is

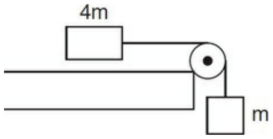


(A) μmg
(B) $\mu(mg - F\sin\theta)$
(C) $\mu(mg + F\sin\theta)$
(D) $\mu(mg - F\cos\theta)$
(E) $\mu(mg + F\cos\theta)$

27. A stone falls through the air toward the Earth's surface. The resistive force the air applies to the stone as it falls is given by the equation $F = cv$, where c is a positive constant and v is the speed of the stone. The acceleration of the ball is given by the equation

(A) $c - g$
(B) gcv/m
(C) $g + cv$
(D) $g - cv/m$
(E) cv/m

28. A block of mass $4m$ can move without friction on a horizontal surface. Another block of mass m is attached to the larger block by a string that is passed over a light pulley. The acceleration of the system is



(A) $\frac{1}{5}g$
(B) $\frac{1}{2}g$
(C) $\frac{2}{3}g$
(D) g
(E) $5g$

29. The block of mass $4m$ in the previous question now moves on a rough surface. The frictional force between the surface and the larger block is equal to $\frac{1}{2}mg$. The acceleration of the system is now

(A) $\frac{1}{16}g$
(B) $\frac{1}{10}g$
(C) $\frac{1}{4}g$
(D) $\frac{1}{2}g$
(E) g

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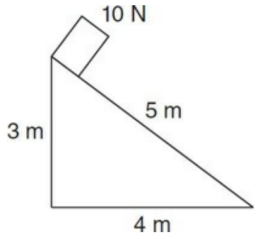
Questions 30-31

A 10 N block sits atop an inclined plane in the shape of a right triangle of sides 3 m, 4 m, and 5 m, as shown. The block is allowed to slide down the plane with negligible friction.



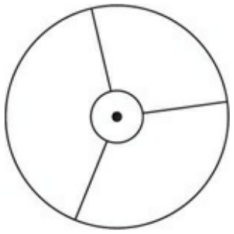
30. The acceleration of the block is most nearly

(A) 2 m/s^2
(B) 4 m/s^2
(C) 6 m/s^2
(D) 10 m/s^2
(E) 12 m/s^2

31. The normal force exerted on the block by the plane is most nearly

(A) 2 N
(B) 4 N
(C) 6 N
(D) 8 N
(E) 10 N

32. Three strings are attached to a ring in the center of a force table. The top view of the force table is shown. For the ring to remain in the center of the table, which of the following must be true?



(A) The vector sum of the three forces must equal zero.
(B) The lengths of the strings must be equal.
(C) The strings must form an angle of 90° relative to each other.
(D) The magnitudes of two of the tensions in the strings must equal the tension in the third string.
(E) The tension in each string must be equal to each other.

Questions 33-34

The position of a 2 kg object is described by the equation $x = 2t^2 - 3t^3$, where x is in meters and t is in seconds.

33. The net force acting on the object at a time of 1 s is

(A) −4 N
(B) −8 N
(C) −14 N
(D) −20 N
(E) −24 N

34. The net force acting on the object is positive from $t = 0$ until a time of

(A) 0.11 s
(B) 0.22 s
(C) 0.44 s
(D) 0.67 s
(E) 1.0 s

Questions 35-36

A particle of mass 0.5 kg moves in two dimensions according to the velocity equation $\mathbf{v} = 4t^2\hat{\boldsymbol{\imath}} + 6t^4\hat{\boldsymbol{\jmath}}$, where speed is in m/s and time is in s.

35. The acceleration of the particle at time $t = 1$ s in m/s^2 is

(A) $a = 8\hat{\boldsymbol{\imath}} + 24\hat{\boldsymbol{\jmath}}$
(B) $a = 24\hat{\boldsymbol{\imath}} + 8\hat{\boldsymbol{\jmath}}$
(C) $a = 8\hat{\boldsymbol{\imath}} + 48\hat{\boldsymbol{\jmath}}$
(D) $a = 4\hat{\boldsymbol{\imath}} + 6\hat{\boldsymbol{\jmath}}$
(E) $a = 2\hat{\boldsymbol{\imath}} + 8\hat{\boldsymbol{\jmath}}$

36. The magnitude of the net force acting on the particle at a time of 2 s is most nearly

(A) 36 N
(B) 64 N
(C) 72 N
(D) 84 N
(E) 104 N

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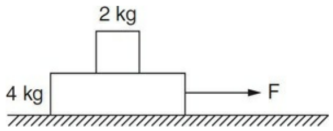
37. A constant force acts on a particle in such a way that the direction of the force is always perpendicular to its velocity. Which of the following is true of the particle's motion?

(A) The acceleration of the particle is increasing
(B) The acceleration of the particle is decreasing.
(C) The speed of the particle is increasing.
(D) The speed of the particle is constant.
(E) The speed of the particle is decreasing.

Questions 38-39

A block of mass 2 kg rests on top of a larger block of mass 4 kg. The larger block slides without friction on a table, but the surface between the two blocks is not frictionless. The coefficient of friction between the two blocks is 0.2. A horizontal force **F** is applied to the 4 kg mass.



38. What is the maximum force that can be applied such that there is no relative motion between the two blocks?

(A) zero
(B) 1 N
(C) 2 N
(D) 4 N
(E) 12 N

39. What is the acceleration of the 2 kg block relative to the 4 kg block if a force is applied to the 4 kg block that causes the 4 kg block to accelerate at 3 m/s^2 to the right?

(A) 1 m/s^2 to the right
(B) 1 m/s^2 to the left
(C) 2 m/s^2 to the right
(D) 2 m/s^2 to the left
(E) zero

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AP® Physics 1 & C: Dynamics
Student Answer Sheet for Multiple-Choice Section

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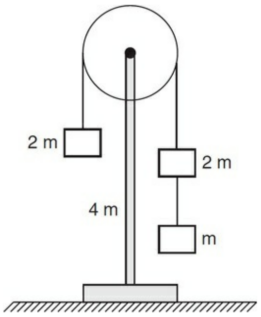
AP PHYSICS 1 & C: DYNAMICS
SECTION II
2 Questions

Directions: Answer all questions. The suggested time is about 10 minutes for answering each of the questions. The parts within a question may not have equal weight. All final numerical answers should include appropriate units. Credit depends on the quality of your solutions and explanations, so you should show your work. Credit also depends on demonstrating that you know which physical principles would be appropriate to apply in a particular situation. Therefore, you should clearly indicate which part of a question your work is for.

1. Three masses are connected by two strings as shown. One of the strings is passed over a pulley of negligible mass and friction. The pulley is attached to a stand that rests on a table. The smallest mass is m, the other two masses each have a mass of $2m$, and the mass of the stand is $4m$.



   (a) If the small mass m is removed, the other two masses hang in equilibrium. Determine the normal force the table exerts on the stand when the system is in equilibrium.

   (b) The small mass m is once again hung below one of the masses of mass $2m$. Determine the acceleration of the system.

   (c) Determine the tension in the string between the block of mass $2m$ and the attached block of mass m while the system is accelerating.

   (d) While the system is accelerating, is the normal force exerted by the table on the stand greater than, equal to, or less than $8mg$? Justify your answer.

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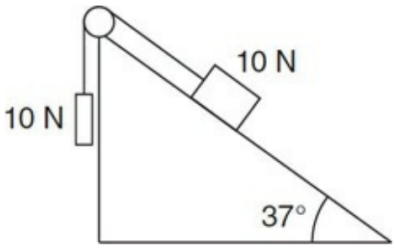
2. Two blocks weighing 10 N each are connected by a light string that is passed over a light pulley. One of the blocks rests on an inclined plane at an angle of 37° to the horizontal. The friction between the inclined plane and the block is such that the system remains at rest. The length of the ramp is 5 m.



(a) Determine the tension in the string while the system is at rest.

(b) Determine the frictional force between the block and the inclined plane while the system is at rest.

(c) If the string is suddenly cut, what is the speed of the block when it reaches the bottom of the plane?