

The Twenty-Ninth Annual SLAPT Physics Contest
Washington University in Saint Louis
April 26, 2014

Mechanics Exam

QUESTION
46
THROWN OUT

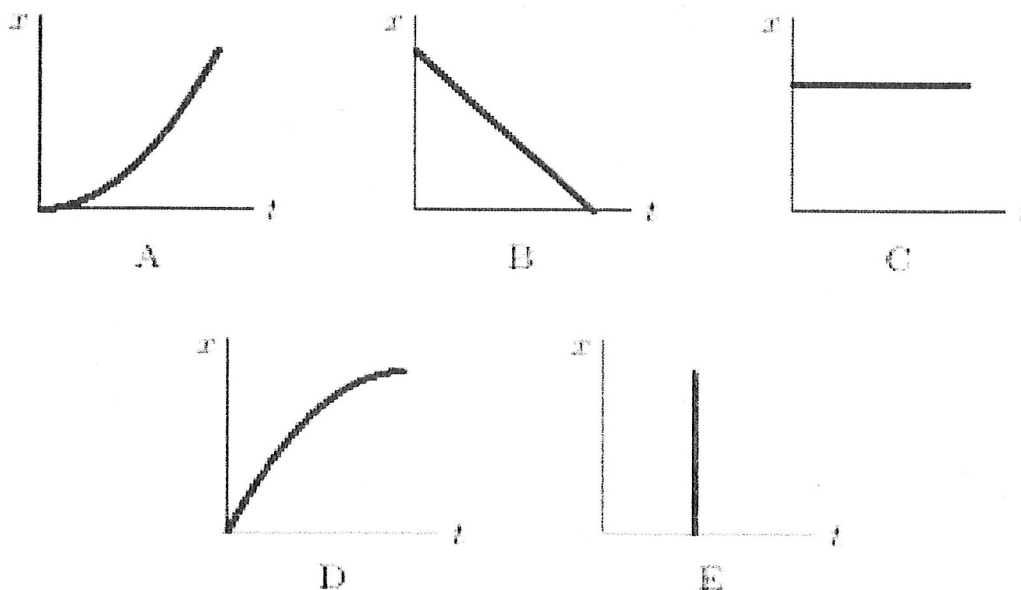
$$g = 9.8 \text{ m/s}^2$$

Please answer the following questions on the supplied answer sheet. You may write on this test booklet and keep it for your records. Only the answer sheets will be scored.

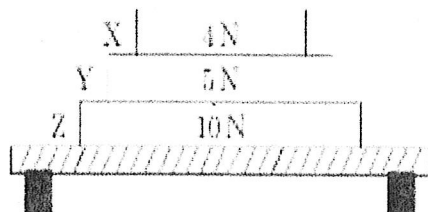
Your sheets must have your name, your school, and MECHANICS on them.

- The average speed of a moving object during a given interval of time is always:
 - the magnitude of its average velocity over the interval
 - the distance covered during the time interval divided by the time interval
 - one-half its speed at the end of the interval
 - the magnitude of its acceleration multiplied by the time interval
 - one-half the magnitude of its acceleration multiplied by the time interval.
- Of the following situations, which one is impossible?
 - A body having velocity east and acceleration east
 - A body having velocity east and acceleration west
 - A body having zero velocity and non-zero acceleration
 - A body having constant acceleration and variable velocity
 - A body having constant velocity and variable acceleration
- At a stop light, a truck traveling at 15 m/s passes a car as the car starts from rest. The truck travels at constant velocity and the car accelerates at 3 m/s^2 . How much time will it take for the car to catch up to the truck?
 - 5 s
 - 10 s
 - 15 s
 - 20 s
 - 25 s
- A 1-kg mass is attached to a compressed spring and the spring is released. If the mass initially has an acceleration of 5.6 m/s^2 , the initial force of the spring has a magnitude of:
 - 2.8N
 - 0
 - 11.2N
 - 5.6N
 - an undetermined amount

5. Which of the following five coordinate versus time graphs represents the motion of an object moving with a constant nonzero speed?



6. Three books (X, Y, and Z) rest on a table. The gravitational force on each book is indicated. The net force on book Y is:



- A. 4 N down
- B. 5 N up
- C. 9 N down
- D. zero
- E. none of these

7. An object is shot from the back of a railroad flatcar moving at constant 40 km/h on a straight horizontal road. The launcher is aimed upward, perpendicular to the bed of the flatcar. The object falls:

- A. in front of the flatcar
- B. behind the flatcar
- C. on the flatcar
- D. either behind or in front of the flatcar, depending on the initial speed of the object
- E. to the side of the flatcar

8. An object moves in a circle. If the mass is tripled, the speed halved, and the radius unchanged, then the centripetal force must change by a factor of:

- A. $3/2$
- B. $3/4$
- C. $9/4$
- D. 6
- E. 12

9. A 400-N steel ball is suspended by a light rope from the ceiling. The tension in the rope is:

- A. 400 N
- B. 800 N
- C. zero
- D. 200 N
- E. 560 N

10. A 90-kg man stands in an elevator that has a downward acceleration of 1.4 m/s^2 . The force exerted by him on the floor is about:

- A. zero
- B. 90 N
- C. 760 N
- D. 880 N
- E. 1010 N

11. The speed of a 4.0-N hockey puck, sliding across a level ice surface, decreases at the rate of 0.61 m/s^2 . The coefficient of kinetic friction between the puck and ice is:

- A. 0.062
- B. 0.41
- C. 0.62
- D. 1.2
- E. 9.8

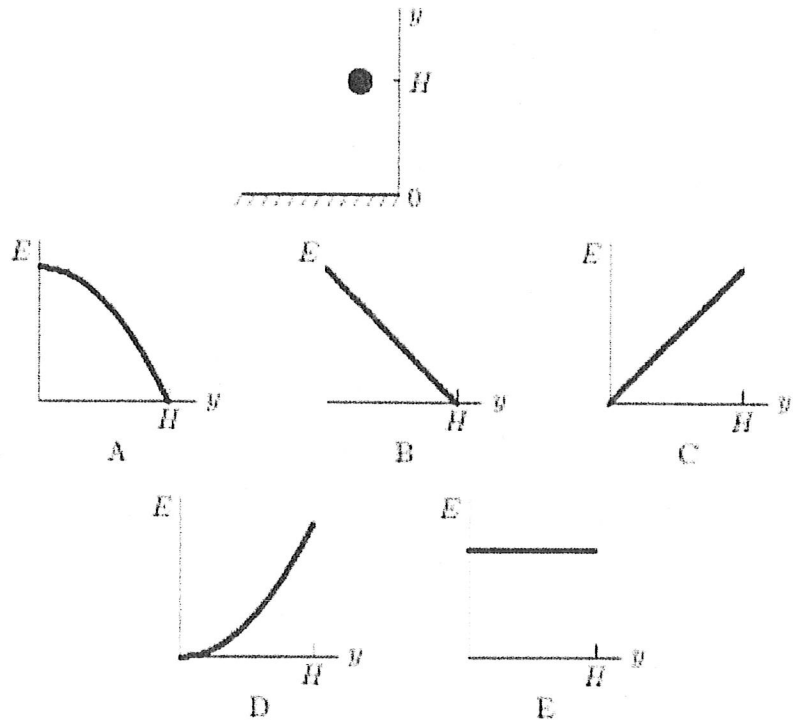
12. A boy holds a 40-N weight at arm's length for 10 s. His arm is 1.5 m above the ground. The work done by the force of the boy on the weight while he is holding it is:

- A. 0 J
- B. 6.1J
- C. 40 J
- D. 60 J
- E. 90 J

13. The weight of an object on the moon is one-sixth of its weight on Earth. The ratio of the kinetic energy of a body on Earth moving with speed V to that of the same body moving with the same speed on the Moon is:

- A. 6:1
- B. 36:1
- C. 1:1
- D. 1:6

14. A ball is held at a height H above a floor. It is then released and falls to the floor. If air resistance can be ignored, which of the five graphs below correctly gives the mechanical energy E of the Earth-ball system as a function of the altitude y of the ball?



15. Whenever an object strikes a stationary object of equal mass:

- A. the two objects cannot stick together
- B. the collision must be elastic
- C. the first object must stop
- D. momentum is not necessarily conserved
- E. none of the above

16. The center of gravity coincides with the center of mass:

- A. always
- B. never
- C. if the center of mass is at the geometrical center of the body
- D. if the gravitational field strength is uniform over the body
- E. if the body has a uniform distribution of mass

17. You walk 47 m to the north, then turn 60° to your right and walk another 45 m. How far are you from where you originally started?

- A. 42 m
- B. 65 m
- C. 80 m
- D. 92 m
- E. 635 m

18. If you forcefully throw an object upwards, its acceleration after it leaves your hand is
- A. Greater than 9.8 m/s^2 and directed upwards
 - B. Greater than 9.8 m/s^2 and directed downwards
 - C. Equal to 9.8 m/s^2 and directed upwards
 - D. Equal to 9.8 m/s^2 and directed downwards
 - E. Less than 9.8 m/s^2 and directed downwards
19. A tightrope walker walks across a 30.0 m long wire tied between two poles. The center of the wire is displaced vertically downward by 1.0 m when he is halfway across. If the tension in both halves of the wire at this point is 6262 N, what is the mass of the tightrope walker? Neglect the mass of the wire.
- A. 43 kg
 - B. 74 kg
 - C. 85 kg
 - D. 91 kg
 - E. 1280 kg
20. A driver in a 1000.0 kg car traveling at 35 m/s slams on the brakes and skids to a stop along a level road. If the coefficient of friction between the tires and the road is 0.80, how long will the skid marks be?
- A. 62 m
 - B. 73 m
 - C. 78 m
 - D. 98 m
21. Suppose you drop a 1 kg rock from a height of 5 m above the ground. When it hits, how much force does the rock exert on the ground?
- A. 0.2 N
 - B. 5 N
 - C. 50 N
 - D. 100 N
 - E. Impossible to determine from the information given
22. A spring has a spring constant of 1734 N/m and it moves horizontally in simple harmonic motion on a frictionless tabletop. If the mass attached to it is 756.7 g, what is the mass's speed as it passes through the equilibrium point? The spring's maximum extension is 31.02 cm.
- A. 0 m/s
 - B. 0.5 m/s
 - C. 14.85 m/s
 - D. 46.4 m/s
23. A 37 g bullet pierces a sand bag 41 cm thick. If the initial bullet velocity was 75 m/s and it emerged from the sandbag with 20 m/s, what is the total magnitude of the friction force the bullet experienced while it traveled through the bag?
- A. 2.4 N
 - B. 24 N
 - C. 97 N
 - D. 240 N

24. A 0.24 kg blob of clay is thrown at a wall with an initial velocity of 20 m/s. If the clay comes to a stop in 91 ms, what is the average force experienced by the clay?

- A. 33 N
- B. 45 N
- C. 53 N
- D. 64 N

25. A compact car and a large truck collide head on and stick together. Which undergoes the larger momentum change?

- A. The car
- B. The truck
- C. The momentum change is the same for both vehicles
- D. Can't tell without knowing the final velocity of the combined mass

26. You are trying to open a door that is stuck by pulling on the doorknob in a direction perpendicular to the door. If you instead tie a rope to the doorknob and pull with the same force, is the torque you exert increased?

- A. yes
- B. no

27. Two wheels, A and B, have identical masses, but the mass of wheel A is spread uniformly over the disk of the wheel, while the mass of wheel B is concentrated on its rim. Which has the larger moment of inertia?

- A. Wheel A
- B. Wheel B
- C. Both wheels have the same moment of inertia
- D. No way to tell given the information provided

28. What is the angular speed of a flywheel turning at 689.0 rpm?

- A. 11.47 rad/s
- B. 54.10 rad/s
- C. 72.15 rad/s
- D. 80.79 rad/s

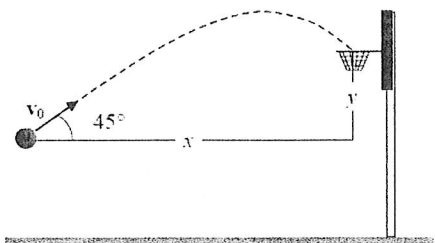
29. What is the angular speed of a flywheel turning at 689.0 rpm?

- A. 11.47 rad/s
- B. 54.10 rad/s
- C. 72.15 rad/s
- D. 80.79 rad/s

30. A basketball is launched with an initial speed of 8.0 m/s and follows the trajectory shown. The ball enters the basket 0.96 s after it is launched. What are the distances x and y ?

Note: The drawing is not to scale.

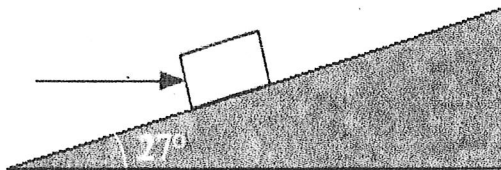
- | | | |
|----|-------|--------|
| | x | y |
| A. | 5.4 m | 0.73 m |
| B. | 7.7 m | 0.91 m |



- | | | |
|----|-------|--------|
| C. | 5.4 m | 0.91 m |
| D. | 5.7 m | 0.73 m |
| E. | 5.4 m | 5.4 m |

31. A 250-N force is directed horizontally as shown to push a 29-kg box up an inclined plane at a constant speed. Determine the magnitude of the normal force, F_N , and the coefficient of kinetic friction, μ_k .

- | | |
|----------|---------|
| F_N | μ_k |
| A. 330 N | 0.31 |
| B. 310 N | 0.33 |
| C. 250 N | 0.27 |
| D. 290 N | 0.30 |
| E. 370 N | 0.26 |



32. A helicopter ($m = 1250$ kg) is cruising at a speed of 25.0 m/s at an altitude of 185 m. What is the total mechanical energy of the helicopter?

- A. 3.91×10^5 J
- B. 2.66×10^6 J
- C. 2.27×10^6 J
- D. 6.18×10^5 J
- E. 1.88×10^6 J

33. A CD-ROM disk can store approximately 600.0 megabytes of information. If an average word requires 9.0 bytes of storage, how many words can be stored on one disk?

- A. 6.7×10^7 words
- B. 5.4×10^9 words
- C. 2.1×10^7 words
- D. 2.0×10^9 words

34. Assuming equal rates of deceleration in both cases, how much further would you travel if braking from 61 mi/h to rest than from 32 mi/h?
- A. 1.9 times further
 - B. 2.9 times further
 - C. 3.6 times further
 - D. 4.3 times further
35. A fisherman casts his bait into the river at an angle of 25° . As the line unravels, he notices that the bait and hook reach a maximum height of 3.9 m. What was the initial velocity he launched the bait with?
- A. 8.4 m/s
 - B. 9.2 m/s
 - C. 10 m/s
 - D. 21 m/s
36. A glider is tugged by an airplane at 81 m/s when it is released. If the original speed was along the horizontal and the glider is now under a constant acceleration of 2.4 m/s^2 at 1.1° below the horizontal due to air drag, how long will it take to reach the ground 5.7 km below?
- A. 100 s
 - B. 500 s
 - C. 1000 s
 - D. 2000 s
37. A 27 kg object is accelerated at a rate of 1.7 m/s^2 . What force does the object experience?
- A. 16 N
 - B. 32 N
 - C. 40 N
 - D. 46 N
38. The engine of a 1250 kg car provides a forward directed force of 3651 N. If the car accelerates at a rate of 2.60 m/s^2 , what is the total resistive force (wind resistance, friction, etc.) acting on the car?
- A. 3651 N
 - B. 3250 N
 - C. 566 N
 - D. 401N
39. Suppose you are playing hockey on a new-age ice surface in which there is no friction between the ice and the hockey puck. You wind up and hit the puck as hard as you can. Just after the puck loses contact with your stick, the puck
- A. Will start to slow down
 - B. Will slow down a little then move at a constant rate
 - C. Will not slow down or speed up
 - D. Will speed up a little, then move at a constant rate

40. An object is moving to the right in a straight line. The net force acting on the object is also directed to the right, but the magnitude of the force is decreasing with time. The object will:
- A. Continue to move to the right, with its speed increasing with time
 - B. Continue to move to the right, with its speed decreasing with time
 - C. Continue to move to the right, with a constant speed
 - D. Stop and start moving to the left
41. A 12 kg block on a table is connected by a string to a 26 kg mass, which is hanging over the edge of the table. If the 12 kg block is 3.1 m from the edge of the table, how much time will pass before the block falls off the table from when the other block is released? Assume that frictional forces may be neglected.
- A. 0.96 s
 - B. 0.82 s
 - C. 0.68 s
 - D. 0.58 s
42. A large truck collides head-on with a cyclist. During the collision
- A. The truck exerts a greater amount of force than the cyclist exerts on the truck
 - B. The truck exerts the same amount of force as the cyclist exerts on the truck
 - C. The truck exerts a lesser amount of force than the cyclist exerts on the truck
 - D. The truck exerts a force on the cyclist, but the cyclist exerts no force on the truck
43. Future space stations will create an artificial gravity by rotating. Consider a cylindrical space station of 390 m diameter rotating about its axis. Astronauts walk on the inside surface of the space station. What rotation period will provide "normal" gravity?
- A. 4.4 s
 - B. 6.3 s
 - C. 14 s
 - D. 28 s
44. A 480 kg car moving at 14.4 m/s hits from behind another car moving at 13.3 m/s in the same direction. If the second car has a mass of 570 kg and a new speed of 17.9 m/s, what is the velocity of the first car after the collision?
- A. -8.94 m/s
 - B. -6.4 m/s
 - C. 6.4 m/s
 - D. 8.94 m/s
45. Three cars, car X, car Y, and car Z, begin accelerating from rest, at the same time. Car X is more massive than car Y, which is more massive than car Z. The net force exerted on each car is identical. After 10 seconds, which car has the most momentum?
- A. Car X
 - B. Car Y
 - C. Car Z
 - D. They all have the same momentum.

46. A 14 cm diameter champagne bottle rests on its side on top of a frictionless table. Suddenly, the cork pops and the bottle slides backward for a distance of 22.0 cm in 0.44 s. If the mass of the bottle is 500 times the mass of the cork, find the distance from the original position the cork will land on the table.

- A. 8.5 cm
- B. 85 cm
- C. 3 m
- D. 6 m

THIS QUESTION WAS
NOT COUNTED IN THE
SCORING OF THE TEST.

47. A 1200 kg cannon fires a 100.0 kg cannonball at 52 m/s. What is the recoil velocity of the cannon? Assume that frictional forces are negligible and the cannon is fired horizontally

- A. 52 m/s
- B. 5.2 m/s
- C. 4.3 m/s
- D. 3.9 m/s

48. A 2.3 kg object moving at 7.3 m/s collides inelastically with a 4.0 kg object which is initially at rest. What percentage of the initial kinetic energy of the system is lost during the collision?

- A. 47 %
- B. 50 %
- C. 58%
- D. 63%

49. A force of 16 N is applied to the end of a 0.63 m-long torque wrench at an angle 45° from a line joining the pivot point to the handle. What is the magnitude of the torque generated about the pivot point?

- A. 0 Nm
- B. 7.1 Nm
- C. 10.1 Nm
- D. 11.3 Nm

50. A traveler pulls on a suitcase strap at an angle 36° above the horizontal. If 908 J of work are done by the strap while moving the suitcase a horizontal distance of 15 m, what is the tension in the strap?

- A. 61 N
- B. 75 N
- C. 85 N
- D. 92 N

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Mechanics Exam Answer Sheet

- | | | | |
|-----|--------------|-----|--------------|
| 1. | B | 42. | B |
| 2. | E | 43. | D |
| 3. | B | 44. | D |
| 4. | D | 45. | D |
| 5. | B | 46. | C |
| 6. | D | 47. | C |
| 7. | C | 48. | D |
| 8. | B | 49. | B |
| 9. | A | 50. | B |
| 10. | C | | |
| 11. | A | | |
| 12. | A | | |
| 13. | C | | |
| 14. | E | | |
| 15. | E | | |
| 16. | D | | |
| 17. | C | | |
| 18. | D | | |
| 19. | C | | |
| 20. | C | | |
| 21. | E | | |
| 22. | C | | |
| 23. | D | | |
| 24. | C | | |
| 25. | C | | |
| 26. | B | | |
| 27. | B | | |
| 28. | C | | |
| 29. | D | | |
| 30. | C | | |
| 31. | E | | |
| 32. | B | | |
| 33. | A | | |
| 34. | C | | |
| 35. | D | | |
| 36. | A | | |
| 37. | D | | |
| 38. | D | | |
| 39. | C | | |
| 40. | A | | |
| 41. | A | | |

NOT COUNTED

C