

THE TWENTY-THIRD ANNUAL SLAPT PHYSICS CONTEST
SOUTHERN ILLINOIS UNIVERSITY EDWARDSVILLE
APRIL 26, 2008
9 – 11 AM

MECHANICS TEST

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

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

The cash prizes for this exam will be:
First Prize of \$100, Second Prize of \$50, and Third Prize of \$25.

Newton Awards will be presented to the next highest scoring twenty percent of the contestants, and certificates to the top three scoring schools.

Award Ceremony at approximately 12:30 in this room

Need something to do until 12:30:

2nd Annual Greater St. Louis Botball Challenge

Robots from 4 states will be converging on the SIUE Campus this Saturday for the 2nd annual Greater St. Louis Botball Tournament. 18 teams from Illinois, Indiana, Michigan and Missouri middle and high schools will put their robots to the test in a head-to-head competition.

When: Saturday, April 26th (today). Doors open at 8 am, Seeding rounds begin at 9:30 am, Double Elimination rounds begin about 1:30 pm

What: Autonomous robots (no remote control!) will save crew and plants on a space station facing a massive solar flare.

Where: The Meridian Ballroom in the Morris University Center

Who: Everyone is welcome! Come see the robots! Cheer on your favorite school!

- 1) The side of a cube is increased by 5%. The percentage increase of the surface area of the cube is,
- 5%
 - 10%
 - 12%
 - 16%
 - 18%
- 2) If an object is located 20 m to the right of the origin at 1:00PM and later the object is located 30 m to the right of the origin at 2:00PM, then the displacement from 1:00PM to 2:00PM is,
- 50 m to the right.
 - 30 m to the right.
 - 25 m to the right.
 - 20 m to the right.
 - 10 m to the right.
- 3) A runner runs 10 m from the origin toward the WEST to point A. He then runs from point A, 20 m more toward the WEST to point B. He then runs from point B, 30 m more toward the EAST to point C. The runner's total distance traveled from the origin to point C is,
- 60 m toward the EAST
 - 50 m toward the EAST.
 - 20 m toward the WEST.
 - 10 m toward the EAST.
 - 60 m
- 4) A car travels at 50 km/hr for 2 hours. It then travels an additional distance of 40 km in 1 hour. The average speed of the car for the entire trip is,
- 61.0 km/hr
 - 57.1 km/hr
 - 53.3 km/hr
 - 46.7 km/hr
 - 30.0 km/hr
- 5) A car traveling at 4.0 m/s has a constant acceleration of 2.0 m/s^2 . If the acceleration lasts for a time of 3.0 seconds, then the average velocity is,
- 5 m/s
 - 7 m/s
 - 9 m/s
 - 11 m/s
 - 13 m/s
- 6) A car starts from rest and travels a distance of 100 m in 10 seconds. The acceleration of the car is,
- 1.0 m/s^2
 - 2.0 m/s^2
 - 2.5 m/s^2
 - 3.0 m/s^2
 - 3.5 m/s^2

7) A 3.0 kg ball is thrown vertically into the air with an initial velocity of 15 m/s. The maximum height of the ball is,

- a) 12.0 m
- b) 11.5 m
- c) 10.0 m
- d) 9.5 m
- e) 9.0 m

8) A car starting from rest travels a distance of 20.0 m with a constant acceleration of 2.0 m/s^2 . The car then slows to a stop in 10.0 seconds with a constant negative acceleration. The distance traveled by the car is,

- a) 36.8 m
- b) 46.2 m
- c) 50.1 m
- d) 58.3 m
- e) 64.7 m

9) A projectile is projected from the origin with a velocity of 45.0 m/s at an angle of 30 degrees above the horizontal. What is the location of the projectile 3.0 seconds later?

- a) X = 85.0 m, Y = 37.0 m
- b) X = 117.0 m, Y = 23.4 m
- c) X = 37.0 m, Y = 117.0 m
- d) X = 23.4 m, Y = 37.0 m
- e) X = 85.0 m, Y = 23.4 m

10) A projectile is projected from the origin with a velocity of 30.0 m/s at an angle of 45 degrees above the horizontal. What is the velocity and time when the projectile hits the ground?

- a) $V_x = 21.2 \text{ m/s}$, $V_y = 21.2 \text{ m/s}$ at $t = 4.33 \text{ s}$
- b) $V_x = 16.7 \text{ m/s}$, $V_y = 16.7 \text{ m/s}$ at $t = 3.33 \text{ s}$
- c) $V_x = 21.1 \text{ m/s}$, $V_y = 16.7 \text{ m/s}$ at $t = 2.83 \text{ s}$
- d) $V_x = 16.7 \text{ m/s}$, $V_y = 21.2 \text{ m/s}$ at $t = 4.33 \text{ s}$
- e) $V_x = 21.2 \text{ m/s}$, $V_y = 15.0 \text{ m/s}$ at $t = 3.33 \text{ s}$

11) A projectile is projected from the origin with a velocity of 30.0 m/s at an angle of 40 degrees above the horizontal. What is the position vector when the projectile is at the maximum height?

- a) X = 45.2 m, Y = 19.0 m
- b) X = 21.1 m, Y = 19.0 m
- c) X = 51.1 m, Y = 21.1 m
- d) X = 45.2 m, Y = 21.1 m
- e) X = 19.0 m, Y = 17.5 m

12) A rocket is launched from the origin with an acceleration of 20.0 m/s^2 at an angle of 30° above the horizontal. The launch acceleration lasts for 2.0 seconds at which time the fuel is exhausted. The rocket then falls with an acceleration of 9.8 m/s^2 downward. What is the maximum height?

- a) 22.3 m
- b) 27.5 m
- c) 30.5 m
- d) 36.7 m
- e) 40.4 m

13) Three objects experience interactions. Object A has mass, object B has electrical charge, and object C has both mass and electrical charge. Object A and object B have a rope connected between them. Which of the following statements are true?

- a) The electrical force on C due to B is equal and opposite to the electrical force on C due to A.
- b) The electrical force on A due to B is equal and opposite to the gravitational force on B due to A.
- c) The rope force on A due to B is equal and opposite to the electrical force on B due to A
- d) The gravitational force on C due to A is equal and opposite to the gravitational force on A due to C.
- e) The rope force on B due to A is equal and opposite to the gravitational force on A due to C

14) A certain spring produces a force F , in N, when it is stretched. The following values of the force F were measured when the spring has a length L , in cm. The force constant of the spring is, in N/cm

Force(N)	0	24	48	72	96	120
L(cm)	4	6	8	10	12	14

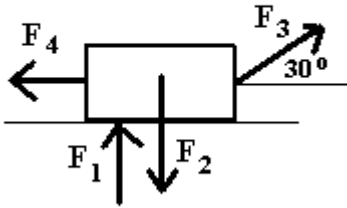
- a) 4.0
- b) 6.0
- c) 7.2
- d) 8.0
- e) 12.0

15) A force of 100 N is applied to an object in a direction that is 60° to the left of the Y axis. The X component and the Y component of the force vector are, in N

- a) $F_x = -50, F_y = +87$
- b) $F_x = +87, F_y = +87$
- c) $F_x = -50, F_y = -50$
- d) $F_x = +50, F_y = +87$
- e) $F_x = -87, F_y = +50$

16) An airplane is flying in horizontal flight at a constant velocity. The weight of the airplane is 40,000 N. The wings produce a lift force that is perpendicular to the wings and a drag force that is parallel to the wing. The engine produces a forward thrust force of 2,000 N. Which of the following statements is true?

- a) The lift force on the airplane is zero.
- b) The drag force on the airplane is zero.
- c) The lift force on the airplane is 42,000 N upward.
- d) The drag force on the airplane is 38,000 N downward.
- e) The drag force on the airplane is 2,000 N backward.

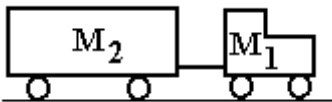


17) The object in the above diagram has four forces applied to it. F_1 is 40 N up, F_2 is 50 N down, F_3 is 40 N to the right at an angle of 30° above the horizontal, and F_4 is 30 N to the left. The net force on the object is, (horizontal to right = + X axis, vertical up = + Y axis)

- a) net $F_x = + 28.3$ N, net $F_y = - 50.0$ N
- b) net $F_x = + 4.6$ N, net $F_y = + 10.0$ N
- c) net $F_x = -30$ N, net $F_y = + 30.0$ N
- d) net $F_x = -10$ N, net $F_y = + 24.6$ N
- e) net $F_x = -18.3$ N, net $F_y = - 40.0$ N

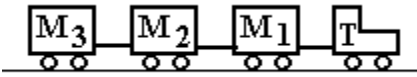
18) A 120 N traffic light is supported by two cables. One cable makes an angle of 35 degrees with the vertical and the other cable makes an angle of 50 degrees with the vertical. The tensions in the cables are,

- a) 84.9 N and 84.9 N
- b) 92.3 N and 69.1 N
- c) 98.7 N and 60.2 N
- d) 102.1 N and 57.3 N
- e) 110.1 N and 55.3 N



19) A tractor of mass $M_1 = 2,000$ kg is pulling a trailer of mass $M_2 = 5,000$ kg. If the tractor-trailer is accelerated at 2.0 m/s^2 , then the tension in the trailer hitch that connects the trailer to the tractor is,

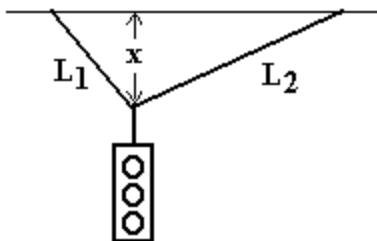
- a) 6,000 N
- b) 8,000 N
- c) 9,000 N
- d) 10,000 N
- e) 11,000 N



- 20) In the figure above, a airport luggage carrying train with a tractor T is pulling three luggage carts, M1, M2, and M3, with constant velocity of 4.5 m/s. If $T = 300$ kg, $M1 = 200$ kg, $M2 = 100$ kg, and $M3 = 100$ kg, then the force in the connection between the tractor T and cart M1 is, in N
- 980 N
 - 560 N
 - 280 N
 - 140 N
 - 0 N

- 21) A 100 Newton box is sliding down an incline at a constant acceleration of 1.5 m/s^2 . The angle of the incline is 20 degrees. The tangential force of friction is,
- 10.2 N
 - 18.9 N
 - 26.3 N
 - 34.8 N
 - 94.0 N

- 22) A student undergoes a first displacement of 3.6 meters at an angle of 20 degrees NORTH of EAST. The student undergoes a second displacement of 7.3 meters at an angle of 40 degrees SOUTH of EAST. The angle of the total displacement is,
- 15 degrees NORTH of EAST
 - 62 degrees SOUTH of EAST
 - 21 degrees SOUTH of EAST
 - 62 degrees NORTH of EAST
 21. degrees NORTH of EAST

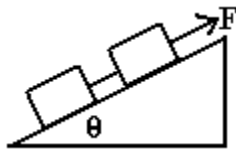


- 23) A 100 N traffic light is suspended by two wires of length $L1$ and $L2$ as shown in the figure. If $L1 = 3.0$ m and $L2 = 5.0$ m and the distance $x = 2.0$ m, then the tension in the wire of length $L1$ is,
- 125 N
 - 101 N
 - 90 N
 - 82 N
 - 75 N



24) A cord with a tension T is passes over a pulley as shown in the figure. The angle θ is 30 degrees and the tension T is 120 N. The force on the pulley by the shaft that supports the pulley is,

- a) $F_x = 60.0 \text{ N}$, $F_y = 16.1 \text{ N}$
- b) $F_x = 16.1 \text{ N}$, $F_y = 60.0 \text{ N}$
- c) $F_x = 60.0 \text{ N}$, $F_y = 60.0 \text{ N}$
- d) $F_x = 30.0 \text{ N}$, $F_y = 90.0 \text{ N}$
- e) $F_x = 90.0 \text{ N}$, $F_y = 30.0 \text{ N}$



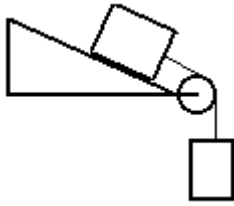
25) Two masses are being pulled up a 30 degrees incline by a force F parallel to the incline. The velocity is constant and up the incline. The force is applied to a 200 kg mass and a string connects the 200 kg mass to a 150 kg mass. The coefficient of kinetic friction is 0.2. The force F is,

- a) 5,870 N
- b) 4,250 N
- c) 3,750 N
- d) 2,310 N
- e) 1,530 N



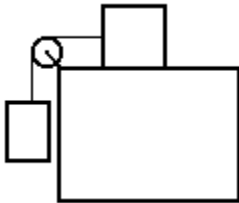
26) Two masses are connected by a string which passes over a frictionless, mass less pulley. One mass hangs vertically and one mass slides on a 30 degrees frictionless incline. The vertically hanging mass is 6.0 kg and the mass on the incline is 4.0 kg. The acceleration of the 4.0 kg mass is,

- a) 0.98 m/s^2
- b) 3.92 m/s^2
- c) 5.75 m/s^2
- d) 6.86 m/s^2
- e) 7.84 m/s^2



27) Two masses are connected by a string which passes over a frictionless, mass less pulley. One mass hangs vertically and one mass slides on a 30 degrees incline. The vertically hanging mass is 4.0 kg and the mass on the incline is 6.0 kg. The acceleration of the 4.0 kg mass is,

- a) 0.98 m/s^2
- b) 3.92 m/s^2
- c) 5.75 m/s^2
- d) 6.86 m/s^2
- e) 7.84 m/s^2



28) Two masses are connected by a string which passes over a frictionless, mass less pulley. One mass hangs vertically and one mass slides on a horizontal surface. The horizontal surface has a coefficient of kinetic friction of 0.2. The vertically hanging mass is 4.0 kg and the mass on the horizontal surface is 6.0 kg. the acceleration of the 4.0 kg mass is,

- a) 1.98 m/s^2
- b) 2.74 m/s^2
- c) 4.88 m/s^2
- d) 6.73 m/s^2
- e) 7.84 m/s^2

29) An object is moving in a circular path of radius 4.0 m. If the object moves through an angle of 30 degrees, then the tangential distance traveled by the object is,

- a) 3.66 m
- b) 3.21 m
- c) 2.84 m
- d) 2.09 m
- e) 1.75 m

30) A CD has a diameter of 12.0 cm. If the CD is rotating at a constant frequency of 6.0 cycles per second, then the angular velocity is,

- a) 21.5 rad/s
- b) 26.9 rad/s
- c) 29.6 rad/s
- d) 33.3 rad/s
- e) 37.7 rad/s

31) A 0.5 kg stone is moving in a circular path (path is perpendicular to the ground) attached to a string that is 75 cm long. The stone is moving around the path at a constant frequency of 2.2 rev/sec. At the moment the stone is at the highest point, the stone is released. The magnitude and direction of the velocity of the stone when it leaves the circular path is,

- a) 10.4 m/s horizontal
- b) 10.4 m/s vertical
- c) 22.0 m/s horizontal
- d) 22.0 m/s vertical
- e) 31.4 m/s horizontal

32) A 2000 kg car is traveling on a banked curved icy road. The velocity of the car is 25 m/s and the road has a radius of curvature of 500 m. If the car is to travel on the icy road without sliding, then the angle of the banked road is,

- a) 25.7 degrees
- b) 21.0 degrees
- c) 12.7 degrees
- d) 10.5 degrees
- e) 7.27 degrees

33) A 95 kg person is standing on a scale to measure weight in an elevator near the surface of the earth. If the elevator is accelerated downward at 4.0 m/s^2 , then the reading on the scale is,

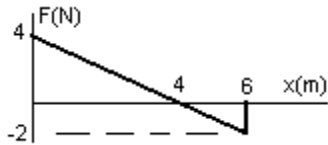
- a) 620 N
- b) 551 N
- c) 500 N
- d) 485 N
- e) 395 N

34) A 20 N force is applied at an angle of 40 degrees above the horizontal to a 4.0 kg box. The box moves a horizontal distance of 4.0 meters. The work done by the 20 N force is,

- a) 75.0 J
- b) 61.3 J
- c) 50.1 J
- d) 46.3 J
- e) 40.5 J

35) A 5.0 kg box slides up a 10 m long friction incline at an angle of 20 degrees with the horizontal pushed by a 40 N force parallel to the incline. The coefficient of kinetic friction is 0.1. The change in kinetic energy is,

- a) 105 J
- b) 145 J
- c) 186 J
- d) 200 J
- e) 243 J



36) The above graph shows the force in the x -direction on an object as it moves a distance x . What is the work done by the force when the object moves from 0.0 m to 6.0 m?

- a) 14 J
- b) 12 J
- c) 10 J
- d) 8 J
- e) 6 J

37) A spring-powered dart gun is un-stretched and has a spring constant 12.0 N/m. The spring is compressed by 8.0 cm and a 5.0 gram projectile is placed in the gun. The velocity of the projectile when it is shot from the gun is,

- a) 1.52 m/s
- b) 2.54 m/s
- c) 3.92 m/s
- d) 4.24 m/s
- e) 5.02 m/s

38) A 2,000 kg car traveling at 30 mph skids to a stop in 60 meters. The coefficient of kinetic friction during the skid is, (1.0 mi/h = 0.447m/s)

- a) 0.15
- b) 0.20
- c) 0.25
- d) 0.31
- e) 0.39

39) A student lifts a weight of 10.0 N a distance of 0.5 meters. If this exercise is repeated 50 times in 100 seconds, then the power of this exercise is,

- a) 2.5 Watts
- b) 3.1 Watts
- c) 3.6 Watts
- d) 4.0 Watts
- e) 4.8 Watts

40) The explosion in a cannon exerts an average force of 30,000 N for L meters, the length of the cannon. The length of the cannon to shoot a 2.0 kg projectile from the cannon on the earth to the moon is,

- a) 2.75 km
- b) 3.01 km
- c) 3.98 km
- d) 4.26 km
- e) 5.02 km

41) A 2.0 kg ball is moving at 4 m/s WEST. The momentum of the ball is,

- a) 4 kg m/s WEST
- b) 6 kg m/s WEST
- c) 8 kg m/s WEST
- d) 10 kg m/s WEST
- e) 12 kg m/s WEST

42) A 4.0 kg ball is moving at 4m/s to the EAST and a 6.0 kg ball is moving at 3.0 m/s to the NORTH. The total momentum of the system is,

- a) 14.2 kg m/s at an angle of 48.4 degrees SOUTH of EAST
- b) 48.2 kg m/s at an angle of 24.2 degrees SOUTH of EAST
- c) 48.2 kg m/s at an angle of 48.4 degrees NORTH of EAST
- d) 24.1 kg m/s at an angle of 24.2 degrees SOUTH of EAST
- e) 24.1 kg m/s at an angles of 48.4 degrees NORTH of EAST

43) An astronaut in a space suit is motionless in outer space. The propulsion unit strapped to her back ejects some gas. The astronaut recoils with a velocity of 1.0 m/s. If the mass of the astronaut and space suit after the gas is ejected is 100 kg and the mass of the gas ejected is 2.5 kg, then the total kinetic energy after the ejection of the gas is,

- a) 2,050 J
- b) 3,430 J
- c) 4,150 J
- d) 5,070 J
- e) 0 J

44) A 4.0 kg object is moving at 5.0 m/s NORTHWEST. It strikes a 6.0 kg that is moving SOUTHWEST at 2.0 m/s. The objects have a completely inelastic (stick together) collision. The velocity of the 6.0 kg object after the collision is,

- a) 2.33 m/s at an angle of 45.0 degrees NORTH of WEST.
- b) 3.89 m/s at an angle of 35.0 degrees NORTH of WEST.
- c) 3.89 m/s at an angle of 14.0 degrees NORTH of WEST.
- d) 2.33 m/s at an angle of 14.0 degrees NORTH of WEST.
- e) 2.33 m/s at an angle of 35.0 degrees NORTH of WEST.

45) A 4.0 kg object is moving at 3.0 m/s WEST. It strikes a 6.0 kg that is moving WEST at 2.0 m/s. The objects have a one-dimensional elastic collision in the EAST-WEST direction. The velocity of the 4.0 kg object after the collision is,

- a) 1.0 m/s WEST
- b) 2.8 m/s WEST
- c) 1.8 m/s WEST
- d) 2.8 m/s EAST
- e) 1.8 m/s EAST

46) A ball collides with a second ball at rest. After the collision, the first ball comes to rest and the second ball moves off at the speed of the first ball. In this collision,

- a) Total momentum is not conserved.
- b) Total kinetic energy is not conserved.
- c) Total momentum is conserved but total kinetic energy is not conserved.
- d) Total momentum is not conserved but total kinetic energy is conserved.
- e) Total momentum and total kinetic energy are conserved and the masses are equal.

47) A 2.0 kg mass is located at (4.0 m, 0.0 m, 0.0 m) and a 4.0 kg mass is located at (0.0 m, 3.0 m, 0.0 m). If this system of masses rotated about the X-axis perpendicular to the Z-Y plane, then the moment of inertia of this system is

- a) 23 kg m²
- b) 28 kg m²
- c) 33 kg m²
- d) 36 kg m²
- e) 41 kg m²

48) A 20 cm wrench is used to generate a torque at a bolt. A force of 50 N is applied perpendicularly at the end of the wrench. The torque generated at the bolt is,

- a) 8 Nm
- b) 10 Nm
- c) 14 Nm
- d) 22 Nm
- e) 37 Nm

49) A 5.0 kg object has a moment of inertia of 1.2 kg m². What torque is needed to give the object an angular acceleration of 2.0 rad/s²?

- a) 2.4 Nm
- b) 2.6 Nm
- c) 2.8 Nm
- d) 3.0 Nm
- e) 3.2 Nm

50) Chris and Jamie are carrying Wayne on a horizontal stretcher. The uniform stretcher is 2.0 m long and weighs 100 N. Wayne weighs 800 N. Wayne's center of gravity is 75 cm from Chris. Chris and Jamie are at the ends of the stretcher. The force that Jamie is exerting to support the stretcher with Wayne on it, is

- a) 250 N
- b) 300 N
- c) 350 N
- d) 400 N
- e) 550 N