1. A force accelerates a body of mass $M$. The same force applied to a second body produces three times the acceleration. What is the mass of the second body?
   A) $M$
   B) $3M$
   C) $M/3$
   D) $9M$
   E) $M/9$

2. A fat cat, ever conscious of its weight, walks into an elevator and steps on a scale. The elevator begins to accelerate downward. While the elevator is accelerating, the scale reads
   A) more than when the elevator is stationary.
   B) more than if the elevator were accelerating upward.
   C) less than when the elevator is stationary.
   D) a negative value.
   E) Insufficient information is given to answer correctly.

3. A ball of mass 2.0 kg is acted on by two forces, $\vec{F}_1 = 3.0 \hat{i} + 4.0 \hat{j}$ and $\vec{F}_2 = -5.0 \hat{i} + 6.0 \hat{j}$. The magnitude of the acceleration is
   A) 2.5 m/s$^2$
   B) 3.9 m/s$^2$
   C) 4.6 m/s$^2$
   D) 5.1 m/s$^2$
   E) 5.8 m/s$^2$
4. A 44.5-N weight is hung on a spring scale, and the scale is hung on a string. The string is lowered at a rate such that the entire assembly has a downward acceleration of 4.90 m/s². The scale reads

A) 0 N  
B) 22.2 N  
C) 44.5 N  
D) 66.7 N  
E) 71.2 N

5. In a crash test the strapped-in, 75-kg dummy moves a distance of 0.80 m when the test car is slammed straight into a wall at 11.2 m/s (~25 mph). The average force acting on the dummy during the collision is how many times his own weight?

A) 0.13  
B) 78  
C) 0.71  
D) 8.0  
E) 4.0

6. We all know it makes sense to bend one's knees when dropping from a height. Suppose a very silly 70-kg person were instead to drop down from a height of 1.4 m onto the ground and stop stiffly within a distance of only 0.60 cm. Calculate how many times his own weight is the average force his body feels.

A) 15  
B) 24  
C) \(2.3 \times 10^3\)  
D) \(6.1 \times 10^2\)  
E) \(2.3 \times 10^2\)
7. A horse-drawn coach is decelerating at 3.0 m/s² while moving in a straight line horizontally. A 350-g mass is hanging on a string 1.6 m long from the ceiling of the coach. The angle that the string makes with the vertical is
A) 9.3º toward the front of the coach.
B) 17º toward the front of the coach.
C) 9.3º toward the back of the coach.
D) 2.5º toward the front of the coach.
E) 0º, or straight down.

8. The tension of the right-hand string divided by the tension of the left-hand string is given by
A) \( \sin \theta_2 / \sin \theta_1 \)
B) \( \cos \theta_1 / \cos \theta_2 \)
C) \( \cos \theta_2 / \cos \theta_1 \)
D) \( \sin \theta_1 / \sin \theta_2 \)
E) \( (mg - T_1 \sin \theta_1) / (T_1 \cos \theta_2) \)

9. The tension in the left-hand string in terms of \( \theta_1 \), \( \theta_2 \), and \( m \) is
A) \( mg \approx \cos \theta_1 / (\sin \theta_1 \sin \theta_2 + \cos \theta_1 \cos \theta_2) \)
B) \( mg \approx \sin \theta_2 / (\sin \theta_1 \sin \theta_2 + \cos \theta_1 \cos \theta_2) \)
C) \( mg \approx \cos \theta_2 / (\sin \theta_1 \sin \theta_2 + \cos \theta_1 \cos \theta_2) \)
D) \( mg \cos \theta_2 / (\sin \theta_1 \cos \theta_2 + \cos \theta_1 \sin \theta_2) \)
E) \( mg \sin \theta_2 / (\sin \theta_1 \cos \theta_2 + \cos \theta_1 \sin \theta_2) \)

10. Two masses, \( m_1 \) and \( m_2 \), connected by a massless string, are accelerated uniformly on a frictionless surface as shown. The ratio of the tensions \( T_1 / T_2 \) is given by

A) \( m_1/m_2 \)
B) \( m_2/m_1 \)
C) \( (m_1 + m_2)/m_2 \)
D) \( m_1/(m_1 + m_2) \)
E) \( m_2/(m_1 + m_2) \)

11. You are riding an elevator that is accelerating upward at 2.20 m/s\(^2\). You have a spring balance accurately calibrated in newtons. When you hang a mass of 10.0 kg on the balance, the reading of the balance is

A) 120 N
B) 981 N
C) 76.0 N
D) 10.0 N
E) 9.81 N

12. A mass \( m \) is hanging on a string that passes over a pulley and is then attached to another mass 3\( m \) that is resting on a horizontal table. Neglect friction. Mass \( m \) is held motionless and is then released. When it has fallen a distance \( h \), it will have a speed \( v \) which can be calculated from the formula

A) \( v = \sqrt{(gh/4)} \)
B) \( v = \sqrt{(gh/2)} \)
C) \( v = \sqrt{(gh)} \)
D) \( v = \sqrt{(2gh)} \)
E) None of these is correct.
13. A 15-kg block sitting on a smooth table is connected to a free-hanging 5-kg mass by a stretchless, massless cord that passes over a small frictionless pulley. The acceleration of the two-block system is
A) equal to $g$.
B) half of $g$.
C) one-third of $g$.
D) one-fourth of $g$.
E) zero.

14. A force of $F = 90$ N is exerted on mass $m_1$ as shown. Both $m_1$ and $m_2$ accelerate to the right at 3 m/s along the frictionless surface. The force $F$ makes an angle of 25 degrees to the horizontal. If $m_2 = 10$ kg, calculate the mass $m_1$.

A) 2.7 kg
B) 17 kg
C) 27 kg
D) 1.8 kg
E) 24 kg

15. Two masses $m_1$ and $m_2$ (with $m_2 > m_1$) are connected by a massless rope hung over a frictionless light pulley. If the masses are released then the acceleration of $m_2$ in the downward direction is given by

A) $(m_2 - m_1) \propto \frac{g}{(m_1 - m_2)}$
B) $(m_2 - m_1) \propto \frac{g}{(m_1 + m_2)}$
C) $(m_1 + m_2) \propto \frac{g}{(m_2 - m_1)}$
D) \( m_2 \propto g/(m_1 + m_2) \)
E) \( g \)

16. A frictionless pulley of negligible mass is hung from the ceiling using a rope, also of negligible mass. Two masses, \( m_1 \) and \( m_2 \) (\( m_1 < m_2 \)) are connected to the rope over the pulley. The masses are free to drop. The magnitude of the tension \( T_{\text{top}} \) is _____ the sum of the weights \( W_1 = m_1 g \) and \( W_2 = m_2 g \).

\[
T_{\text{top}} = m_1 g + m_2 g
\]

A) less than
B) equal to
C) greater than
D) unable to tell
E) depends on \( T_1 \) and \( T_2 \).

17. A mass \( M = 5.6 \text{ kg} \) on a horizontal table is pulled by a horizontal string that passes over a frictionless pulley to a free-hanging mass \( m = 3.4 \text{ kg} \). The coefficient of friction between \( M \) and the table is 0.28. The acceleration of \( M \) is

A) 3.7 m/s\(^2\)
B) 2.0 m/s\(^2\)
C) 2.2 m/s\(^2\)
D) 0.20 m/s\(^2\)
E) 0.49 m/s\(^2\)
18. A mass \( m_2 = 1.5 \) kg rests on a horizontal table. The coefficients of friction between \( m_2 \) and the table are \( \mu_s = 0.3 \) and \( \mu_k = 0.25 \). The mass \( m_2 \) is attached by strings to masses \( m_1 = 2.5 \) kg and \( m_3 = 4.5 \) kg as shown. Masses \( m_1 \) and \( m_3 \) hang freely. The system is initially held at rest. After it is released, the acceleration of \( m_2 \) is approximately

A) 1.9 m/s\(^2\)
B) 2.4 m/s\(^2\)
C) 3.0 m/s\(^2\)
D) zero
E) 13 m/s\(^2\)

19. A 100-kg block is pushed up a 30° incline that is 10 m long. If the coefficient of friction between the block and the incline is 0.1, the constant force parallel to the incline that is required to move the block from rest at the bottom of the incline to the top in 3 s is approximately

A) 0.49 kN
B) 0.085 kN
C) 0.22 kN
D) 0.80 kN
E) 0.58 kN

20. A block of mass \( m_b \) rests on a horizontal surface and is accelerated by means of a horizontal cord that passes over a frictionless peg to a hanging weight of mass \( m_w \). The coefficient of kinetic friction between the block and the horizontal surface is \( \mu \) and the tension in the cord is \( T \). The acceleration of the block is given by

A) \((T - m_wg)/(m_w + m_b)\)
B) \(T/(\mu m_b g + m_b)\)
C) \((T - \mu m_b)/m_b\)
D) \((m_w g - T)/m_w\)
E) \(T/m_b - \mu m_b g\)
21. An object with a mass of 5.5 kg is allowed to slide from rest down an inclined plane. The plane makes an angle of 30° with the horizontal and is 72 m long. The coefficient of friction between the plane and the object is 0.35. The speed of the object at the bottom of the plane is

A) 5.3 m/s  
B) 15 m/s  
C) 24 m/s  
D) 17 m/s  
E) 11 m/s

22. A block of mass \( m \) is pulled in the direction shown in the figure across a rough surface at a constant velocity. The magnitude of the frictional force is

\[ \text{A) } \mu_k mg \]  
\[ \text{B) } \mu_k T \cos \theta \]  
\[ \text{C) } \mu_k (T - mg) \]  
\[ \text{D) } \mu_k T \sin \theta \]  
\[ \text{E) } \mu_k (mg - T \sin \theta) \]

23. An object with a mass of \( m = 12.0 \text{ g} \) is falling through a resistive fluid in which \( g \) is constant. The retarding frictional force due to the fluid is \( F = bv \), where \( F \) is the force in newtons, \( b \) is a constant, and \( v \) is the speed in meters per second. If \( F = 3.2 \times 10^{-2} \text{ N} \) when \( v = 16.0 \text{ m/s} \), the terminal speed of the object falling through the fluid is

\[ \text{A) } 0.12 \text{ m/s} \]  
\[ \text{B) } 59 \text{ m/s} \]  
\[ \text{C) } 0.19 \text{ km/s} \]  
\[ \text{D) } 16.0 \text{ m/s} \]  
\[ \text{E) } \text{None of these is correct.} \]
24. A particle is moving uniformly in a circle with radius 50 cm. The linear speed of the particle is 60 cm/s. The acceleration of the particle has a magnitude of
A) zero
B) 36 m/s²
C) $1.8 \times 10^5$ cm/s²
D) 72 cm/s²
E) 3.6 m/s²

25. A proud new Jaguar owner drives her car at a speed of 25 m/s into a corner. The coefficients of friction between the road and the tires are 0.70 (static) and 0.40 (kinetic). What is the minimum radius of curvature for the corner in order for the car not to skid?
A) $3.5 \times 10^2$ m
B) 64 m
C) $2.1 \times 10^2$ m
D) $1.6 \times 10^2$ m
E) 91 m

26. A professor likes to demonstrate centripetal force by swinging a bucket of water in the vertical direction. What is the minimum speed he must swing the bucket at the top of the circle if he is not to get drenched? (Assume that his arm is 1 m long.)
A) 1.1 m/s
B) 2.1 m/s
C) 3.1 m/s
D) 4.1 m/s
E) 5.1 m/s

27. An L-shaped piece, represented by the shaded area on the figure, is cut from a metal plate of uniform thickness. The point that corresponds to the center of mass of the L-shaped piece is
A) 1
B) 2
C) 3
D) 4
E) 5
28. Three smiley faces are situated along the $x$ axis as follows: $m_1 = 5 \text{ kg at 3.0 m}$, $m_2 = 3 \text{ kg at 6.0 m}$ and $m_3 = 2 \text{ kg at 8.0 m}$. Where is the center of mass situated?

A) 3.9 m  
B) 4.9 m  
C) 5.5 m  
D) 4.1 m  
E) 5.1 m

29. A 1.0-kg mass is acted on by a net force of 4.0 N and a 3.0-kg mass is acted on by a net force of 3.0 N, in the directions shown. The acceleration of the center of mass of this system is approximately

A) $1.3 \text{ m/s}^2$, 53º N of E  
B) $1.8 \text{ m/s}^2$, 45º N of E  
C) $4.0 \text{ m/s}^2$, due north  
D) $5.0 \text{ m/s}^2$, N of E  
E) $7.0 \text{ m/s}^2$, 53º N of E

30. A bullet with a mass of 12 g moving horizontally strikes a fixed block of wood and penetrates a distance of 5.2 cm. The speed of the bullet just before the collision is 640 m/s. The average force that the wood exerted on the bullet was

A) $4.7 \times 10^4 \text{ N}$  
B) 74 N  
C) $4.7 \times 10^6 \text{ N}$  
D) unknown; the mass of the wood is required
E) None of these is correct.

31. Kids love to crash their toy cars together. One such collision involves a 0.5 kg car moving at 0.3 m/s colliding with a stationary toy car of mass 0.3 kg. The two toys stick together and move away from the collision point at 0.188 m/s. By what factor is the initial kinetic energy greater than the final kinetic energy?

A) 0.63  
B) 1.6  
C) 2.5  
D) 4.2  
E) 1.0 The kinetic energy stays the same.

32. What is the difference in work needed to push a 100 kg crate (at constant speed) a distance of 2 m along an inclined plane that is at an angle of 20 degrees with the horizontal, if the coefficient of kinetic friction was equal to 0.20 or zero?

A) 670 N  
B) 1040 N  
C) no difference  
D) 370 N  
E) 134 N

33. A motor is lifting a mass of 35.0 kg at a constant speed of 6.00 m/s. If friction is neglected, the power developed by the motor to do this lifting is

A) 740 W  
B) \(1.5 \times 10^3\) W  
C) \(2.1 \times 10^3\) W  
D) 59 W  
E) 43 W

34. Power \(P\) is required to lift a body a distance \(d\) at a constant speed \(v\). What power is required to lift the body a distance \(2d\) at constant speed \(3v\)?

A) \(P\)  
B) \(2P\)  
C) \(3P\)  
D) \(6P\)  
E) \(3P/2\)
35. What is the power output needed from a motor to lift, in the absence of friction, a mass of $1.5 \times 10^4$ kg 25 m in 6.0 s at constant speed?
A) $2.0 \times 10^6$ W
B) $6.1 \times 10^5$ W
C) $2.2 \times 10^4$ W
D) $8.3 \times 10^5$ W
E) $3.1 \times 10^5$ W

36. A body is acted upon by a force of 10 N and undergoes a displacement in the direction of the force in accordance with the relation $s = 3t^2 + 2t$, where $s$ is the displacement in meters and $t$ is in seconds. The rate at which the force is doing work at the instant $t = 2$ s is
A) 14 W
B) 12 W
C) 120 W
D) 140 W
E) 160 W

37. As a punishment for being late to a practice session the coach orders her star athlete to run up the stadium steps. The player's mass is 80 kg and it takes one minute for her to run up the 120 steps at a constant rate. If each step is of height 0.5 m, what is the power output of the player?
A) 80.0 W
B) 13.0 W
C) 1570 W
D) 785 W
E) 390 W

38. What minimum power rating must a water pump have if needs to raise water at 20 kg per minute from a depth of 9 m?
A) 1.76 kW
B) 29.4 W
C) 106 kW
D) 3.0 W
E) 180 W
39. A 6.0-kg block slides from rest at position A down a frictionless incline to position B. The speed of the block at B is
A) 3.1 m/s  
B) 4.4 m/s  
C) 11 m/s  
D) 1.8 m/s  
E) 20 m/s

40. A 5200-kg cable car in Hong Kong is pulled a distance of 360 m up a hill inclined at 12° from the horizontal. The change in the potential energy of the car is
A) $1.8 \times 10^7$ J  
B) $1.2 \times 10^7$ J  
C) $3.8 \times 10^6$ J  
D) $6.0 \times 10^7$ J  
E) $1.8 \times 10^6$ J

41. A projectile of mass $m$ is propelled from ground level with kinetic energy of 450 J. At the exact top of its trajectory, its kinetic energy is 250 J. To what height above the starting point does the projectile rise?
A) \( \frac{450}{mg} \) m  
B) \( \frac{250}{mg} \) m  
C) \( \frac{700}{mg} \) m  
D) \( \frac{200}{mg} \) m  
E) \( \frac{350}{mg} \) m
42. Release mass $m$ on a string from rest at point A. As it passes the lowest point B, the tension in the string is
A) impossible to determine; the answer depends on the length of the string.
B) $mg$
C) $2mg$
D) $3mg$
E) None of these is correct.

43. A woman on a bicycle traveling at 10 m/s on a horizontal road stops pedaling as she starts up a hill inclined at 3.0° to the horizontal. If friction forces are ignored, how far up the hill does she travel before stopping?
A) 5.1 m
B) 30 m
C) 97 m
D) 10 m
E) The answer depends on the mass of the woman.

44. A child is sitting on the seat of a swing with ropes 10 m long. Her father pulls the swing back until the ropes make a 37° angle with the vertical and then releases the swing. If air resistance is neglected, what is the speed of the child at the bottom of the arc of the swing when the ropes are vertical?
A) 11 m/s
B) 8.8 m/s
C) 14 m/s
D) 6.3 m/s
E) 12 m/s
45. A 5-kg box is pushed 5 m up a plane that is inclined at 30º with the horizontal. The coefficient of kinetic friction between the box and the plane is 0.20. The change in potential energy of the box is approximately
A) 12.5 J
B) 34.2 J
C) 123 J
D) 345 J
E) 403 J

46. A 4.0-kg block starts from rest and slides 5.0 m down a plane inclined at 60º to the horizontal. The coefficient of kinetic friction between the surface and the block is 0.20. The work done by friction on the block is
A) 98.0 J
B) 19.6 J
C) 3.92 J
D) 3.40 J
E) 64.0 J

47. A 10-kg box is pushed up a plane inclined at 37º with the horizontal. The box starts from rest and is pushed 5 m along the incline with a uniform acceleration of 2 m/s². The coefficient of kinetic friction is 0.20 and the pushing force is parallel to the plane. The increase in the potential energy of the box is
A) 0.10 kJ
B) 0.29 kJ
C) 0.36 kJ
D) 0.46 kJ
E) 0.39 kJ
48. The surface shown in the figure is frictionless. If the block is released from rest, it will compress the spring at the foot of the incline

A) 4.00 m  
B) 3.24 m  
C) 1.57 m  
D) 0.989 m  
E) None of these is correct.

49. A 5-kg blob of putty is dropped from a height of 10.0 m above the ground onto a light vertical spring the top of which is 5 m above the ground. If the spring constant \( k = 200 \text{ N/m} \) and the blob compresses the spring by 1.50 m, then find the amount of energy lost in sound and thermal energy.

A) 20.0 J  
B) 169 J  
C) 266 J  
D) 438 J  
E) 94.0 J

50. A mass \( m \) is released from a height 60 cm from the right-hand side of the track shown in the diagram at right. There is only friction acting on the mass on the horizontal portion 35 cm either side of the midpoint O, with a kinetic coefficient of friction of \( \mu_k = 0.5 \). Determine what is the velocity of the block the first time it passes through the midpoint, and on which side of the midpoint does it stop?
A 3-kg block sits on an incline where the top half of the incline has a coefficient of kinetic friction of 0.5 and the bottom half is frictionless. The angle of inclination is 35 degrees. If the block is released and travels 10 m along the rough part of the incline and then 10 m along the smooth part before it makes contact with the spring (k = 200 N/m), calculate the distance the spring is compressed.

A) 1.47 m
B) 1.56 m
C) 2.16 m
D) 2.43 m
E) 1.39 m
Answer Key - practice questions for exam 2

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