Name:

ID:

There is a sheet of useful formula and values of constant at the end. Circle your answers clearly. All problems are 3.5 points each except for problems 14-18. Maximum score is 102.

1. According to Einstein, $E = mc^2$ for an object with mass m (c is the speed of light). The units of E are
   a. kg m/s **b. kg m^2/s^2**
   c. kg^2 m d. kg/m

2. An object is thrown straight upward from the edge of a cliff which is 20 m high. The object rises 15 m and then falls to the base of the cliff. Choosing the positive x to be up, the rock's displacement is:
   a. 20 m b. -15 m
   c. -20 m d. 55 m

3. A person runs from home to the store and back again, a total distance of 1 mi. The trip including the stop at the store takes 20 minutes. The person's average velocity is:
   a. 3 mi/hr **b. 0 mi/hr**
   c. 6 mi/hr d. it depends on how long the person stayed at the store

4. The plot of x vs. t for an object's motion is a parabola. The acceleration of the object is
   a. zero **b. constant** c. variable

5. A car starts from rest and accelerates at 3 m/s^2 for 30 s. It travels at constant speed for 60 s and then slows down at a rate of 2 m/s^2. The total distance it covers is:
   a. 7470 m b. 7425 m
   c. 5400 m **d. 8775 m**

6. A ball is thrown straight up with a speed of 10 m/s from a cliff of height 15 m. Its speed when it reaches the ground is
   a. 17.1 m/s **b. 19.8 m/s**
   c. 29.9 m/s d. 9.9 m/s

7. Vector A has an x component of 3 and a y component of 4. The angle A makes with the x axis is
   a. 53.1^o b. 36.9^o
   c. 45^o d. 23.1^o

8. You walk 100 m due south and then turn and walk 50 m in a direction 45^o north of east. What is the magnitude of your total displacement?
   a. 150 m b. 135.4 m
   c. 73.7m d. 64.6 m

9. A projectile is launched at an angle of 30^o with the horizontal with a speed of 100 m/s. When it reaches its maximum altitude its speed is
   a. 50 m/s b. 100 m/s
   c. 25 m/s **d. 87 m/s**

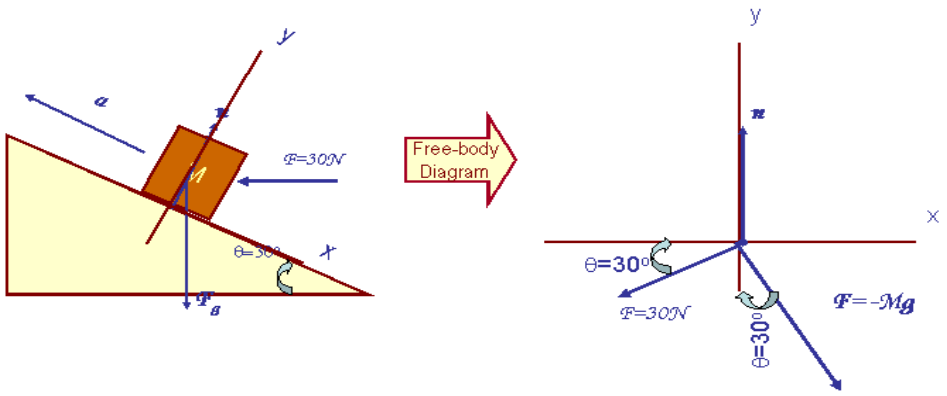
10. Which of the following is not an inertial frame of reference?
a. a speed-racing car moving at constant velocity
b. a car turning the corner
c. an inclined plane
d. a plane flying at constant velocity and dropping aid packages

11. A block sits on a frictionless surface. A horizontal force of 10 N applied to the block moves it 30 m in 15 s. The mass of the block is
a. 26 kg
b. 37 kg
c. 44 kg
d. 100 kg

12. A person stands on a scale in a free falling elevator. The reading on the scale is
a. zero
b. less than the person's weight, but not zero
c. the person's true weight
d. more than the person's true weight

13. A 5 kg block slides down a frictionless plane inclined at 30^o with the horizontal. The acceleration of the block is
a. 4.9 m/s^2
b.9.8 m/s^2
c. 8.5 m/s^2
d. need to know the mass of the block

14-18] A 5 kg block is placed on a frictionless inclined plane of angle 30^o and pushed up the plane with a horizontal force of magnitude 30 N. The magnitude of the block's acceleration is
14. Draw a free-body diagram for this motion. (4 points)



15. What is the direction of gravitational force in this motion? (3.5points)
a. Along the incline toward the bottom
b. Along the incline toward the top
c. Down toward the center of the earth
d. Cannot determine with the given information

16. What are the direction and magnitude of block's acceleration? (3 points each totaling 6 points)

Answer]

$$\sum F_x = Mg\sin 30^\circ - F\cos 30^\circ = Ma_x$$

$$a_x = \frac{Mg\sin 30^\circ - F\cos 30^\circ}{M} = \frac{5\cdot 9.8\cdot \sin 30^\circ - 30\cdot\cos 30^\circ}{5} = -0.30 m/s^2$$

$$\sum F_x = n - Mg\cos 30^\circ - F\sin 30^\circ = Ma_y = 0; a_y = 0$$

Thus, the acceleration is up the incline along the direction of the incline. The magnitude of the acceleration is $a = \sqrt{a_x^2 + a_y^2} = \sqrt{(-0.30)^2} = 0.30 m/s^2$

17. What is the magnitude of force exerted on the plane by the block? (4 points)

Answer] Since the force exerted by the box on the plane is balanced by the normal force, the magnitude of this force is the same as normal force:

$$\sum F_x = n - Mg\cos 30^\circ - F\sin 30^\circ = 0$$

$$n = Mg\cos 30^\circ + F\sin 30^\circ = 5\cdot 9.8\cdot\cos 30^\circ + 30\sin 30^\circ = 57 N$$

18. What is the smallest horizontal force needed to move the block up the plane? (4 points)

Answer] Horizontal force needed to push the block up the incline must provide sufficient upward force component along the incline that can overcome the downward force component by the gravitational force. Thus

$$\sum F_x = Mg\sin 30^\circ - F\cos 30^\circ > 0$$

$$F > \frac{Mg\sin 30^\circ}{\cos 30^\circ} = 5\cdot 9.8\cdot\tan 30^\circ = 28N$$

$$F = 28N$$

19. A block of mass 5 kg lies on a table. It is not moving and you are not pulling or pushing on it. The coefficients of static and kinetic friction are 0.4 and 0.3 respectively. The force of friction on this object is
   a. 0 N
   b. 15 N
   c. 20 N
   d. 49 N

20. An object slides down an inclined plane at constant velocity. From this we conclude
   a. the incline is frictionless
   b. the net force on the object is directed down the plane
   c. there is a frictional force
   d. there is no normal force on the object

21. A block is released at the top of a plane inclined at 30° with the horizontal. The block travels 1 m in 2 s. What is the coefficient of kinetic friction between the block and the plane?
   a. 0.3
   b. 0.4
   c. 0.5
   d. 0.7

22. A bucket of mass 2 kg is whirled in a vertical circle of radius 1 m. At the lowest point of its motion the tension in the rope supporting the bucket is 25 N. The speed of the bucket is
a. 1.6 m/s b. 2.7 m/s
c. 4.7 m/s d. 5.6 m/s

23-24] A block of mass 5 kg lies on a table. It is not moving and you are not pulling or pushing on it. The coefficients of static and kinetic friction are 0.4 and 0.3 respectively.

23. In the above problem a horizontal force of 17 N is now applied to the block. Will it move?
a. yes **b. no**

24. In the above problem suppose you turn the box on its side so that there's a smaller surface area in contact with the table. The reading on the spring scale just as the box starts to move as compared with the previous problem is
a. greater b. smaller **c. the same**

25. The gravitational force exerted on the Earth by a 10 kg object sitting on the Earth's surface is
a. zero N b. 9.8×10^{-11} N
c. 98 N d. 6.7×10^{-13} N

26. Two objects with masses m_1 and m_2 are located a distance d apart. If their masses are each doubled and the separation between them is reduced to d/2, by what factor does the gravitational force between them change?
a. 1/16 b. 1/2
c. 4 **d. 16**

27. Three 5 kg masses sit at the vertices of an equilateral triangle of side 1m. The magnitude of the gravitational force on any of the masses due to the other two in the absence of the Earth's gravitation is
a. 1.2×10^{-11} N b. 2.5×10^{-10} N
c. 2.9×10^{-9} **N** d. 3.4×10^{-8} N

28. In the above problem the net force on each of the vertices points
a. away from the center of the triangle
b. toward the center of the triangle
c. along a line joining two of the masses
d. cannot be determined

Useful Formula and values of constants

1-dimensional Kinetic formula

$$v_f = v_i + at$$

$$x_f = x_i + v_{xi}t + \frac{1}{2}a_x t^2;\ y_f = y_i + v_{yi}t + \frac{1}{2}a_y t^2$$

$$v_f^2 = v_i^2 + 2a(x_f - x_i)$$

Centripetal acceleration: $a_r = \frac{v^2}{r}$

Newton's 2nd law of motion: $\sum F_x = ma_x;\ \sum F_y = ma_y$

Gravitational acceleration is $g = 9.8 m/s^2$.

Newton's universal law of gravitation: The gravitational force between the two objects of masses m1 and m2 is proportional to their masses and inversely proportional to the square of the distance between them.

$$F_G = \frac{Gm_1m_2}{r^2},$$

where the gravitational constant is $G = 6.67\times10^{-11} N\cdot m^2/kg^2$.

The solutions for a 2-dimensional equation:

$$ax^2 + bx + c = 0$$

are:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$