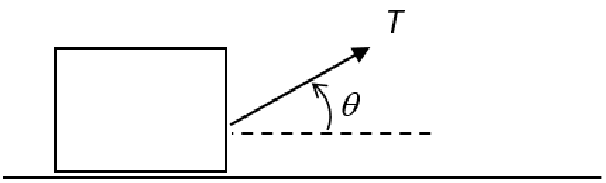
The next three questions pertain to the situation described below.



A physics student is trying to pull a box of books of mass m = 40 kg across the floor as shown in the figure. The coefficient of static friction μ_s = 0.49 and the coefficient of kinetic friction μ_k = 0.35.

1) If the student pulls horizontally (θ = 0°), the normalforce N is

a. N < mg
b. N > mg
c. N = mg

2) The box is originally at rest and the student pulls at an angle θ = 37°. What is the minimum tension, T, required to start the box moving?

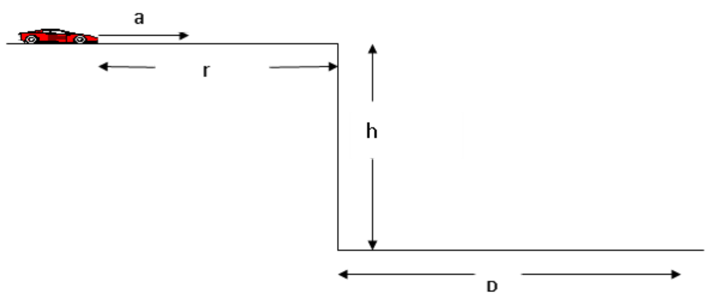
a. T_{min} = 176 N
b. T_{min} = 241 N
c. T_{min} = 319 N
d. T_{min} = 148 N
e. T_{min} = 136 N

3) If the student applies the minimum force required get the box moving for a period of 5 seconds. Which of the following best describes the the motion of the box?

a. The box will continue to move at a constant speed for the 5 seconds.
b. The velocity of the box will continue to increase over the 5 seconds.
c. The box will start moving, but then slow down to a stop during the 5 seconds.

The next three questions pertain to the situation described below.

An empty car is driven off of a cliff as part of a stunt for a new movie. The car starts at rest and then undergoes a constant acceleration of a= 6 m/s^2 for a distance r = 100 m. The car then goes off the cliff, leaving the cliff travelling parallel to the ground. The cliff is a height h = 75 m above the ground below. (As usual, we will neglect air resistance.)



4) Which of the following is a valid expression for the time the car is in the air?

a. $t = hr/Dg$
b. $t = \sqrt{ha/g^2}$
c. $t = \sqrt{2h/g}$
d. $t = \sqrt{hr/Dg}$
e. $t = h/g$

5) What is the speed of the car just before it hits the ground?

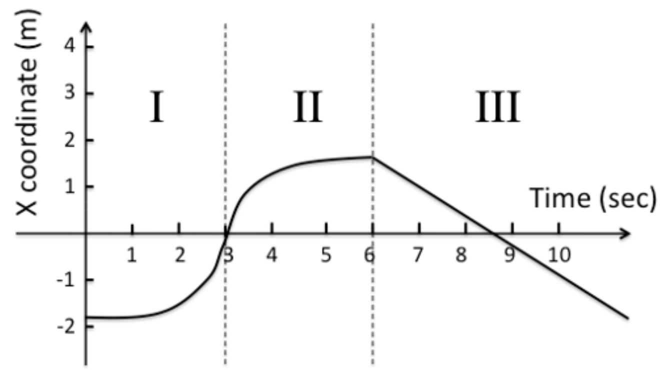
a. v_{impact} = 34.6 m/s
b. v_{impact} = 27.1 m/s
c. v_{impact} = 73 m/s
d. v_{impact} = 51.7 m/s
e. v_{impact}= 3.72 m/s

6) If the initial acceleration of the car was doubled (a_2 = 12 m/s^2), how would the new distance the car lands from the cliff, D_2 compare to the original distance D?

a. $D_2 = 2D$
b. $D_2 = 4D$
c. $D_2 = \sqrt{2}D$

The next three questions pertain to the situation described below.

A particle is subject to a force F that is changing in time. The figure shows the x-coordinate of that particle's position as a function of time. The trajectory of the particle is divided into three regions as indicated in the figure.



7) Which of the following correctly describes $\overline{F_x}$, the average value of the x-component of the force in region I ?

a. $\overline{F_x} < 0$
b. $\overline{F_x} > 0$
c. $\overline{F_x} = 0$

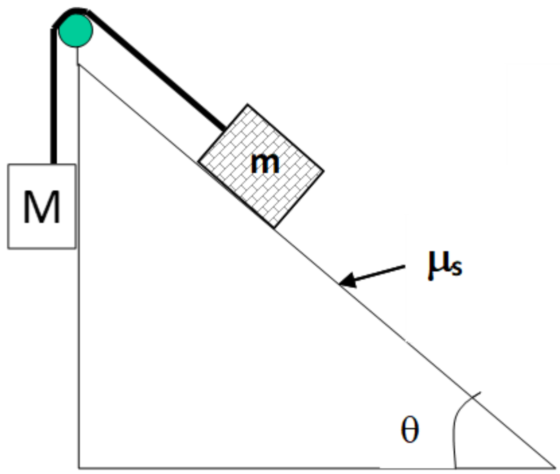
8) In region II, the particle's speed is

a. increasing.
b. decreasing.
c. constant.

9) In region III, which of the following applies to the x-component of the particle's velocity

a. $v_x < 0$
b. $v_x > 0$
c. $v_x = 0$

The next two questions pertain to the situation described below.



An inclined plane with angle θ has a rough top surface with coefficient of static friction μ_s and kinetic friction μ_k. A mass, *m*, sits at rest with respect to the plane and is attached by an ideal string over a massless pulley to a hanging mass, *M*.

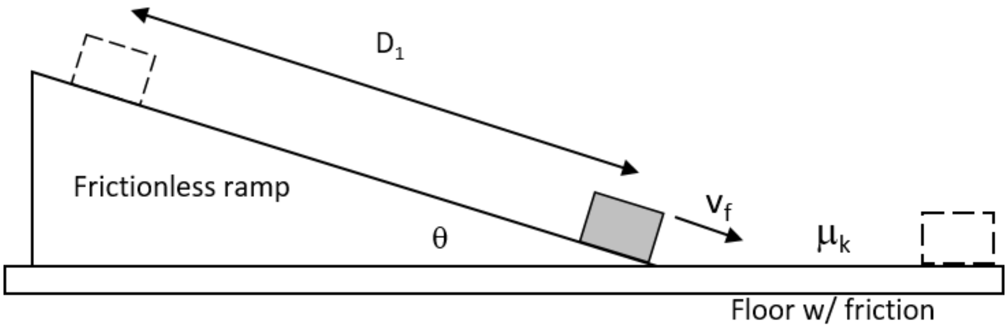
10) Which of the following is the correct expression for the maximum value of the hanging mass, M_{max}, such that the mass, *m*, remains stationary on the plane?

a. $M_{max} = m(\tan\theta + \mu_s)$
b. $M_{max} = m \sin\theta$
c. $M_{max} = m(\sin\theta - \mu_s\cos\theta)$
d. $M_{max} = m(\sin\theta + \mu_s\cos\theta)$
e. $M_{max} = m\,\mu_s \tan\theta$

11) The string is suddenly cut and the mass *m* begins to slide down the plane with an acceleration, *a*. What is the correct expression for μ_k

a. $\mu_k = (g\sin\theta - a) / (g\cos\theta)$
b. $\mu_k = (mg\sin\theta - a) / \cos\theta$
c. $\mu_k = \tan\theta$
d. $\mu_k = a\tan\theta/g$
e. $\mu_k = (a+g\tan\theta)/\cos\theta$

The next three questions pertain to the situation described below.



A 7 kg block starts at rest and slides down a frictionless ramp that makes an angle θ=26 degrees with respect to the horizontal floor below. At the bottom of the ramp, after having slid a distance D_1, the speed of the block is observed to be 18 m/s.

12) What is the distance D_1 that the block slid along the ramp?

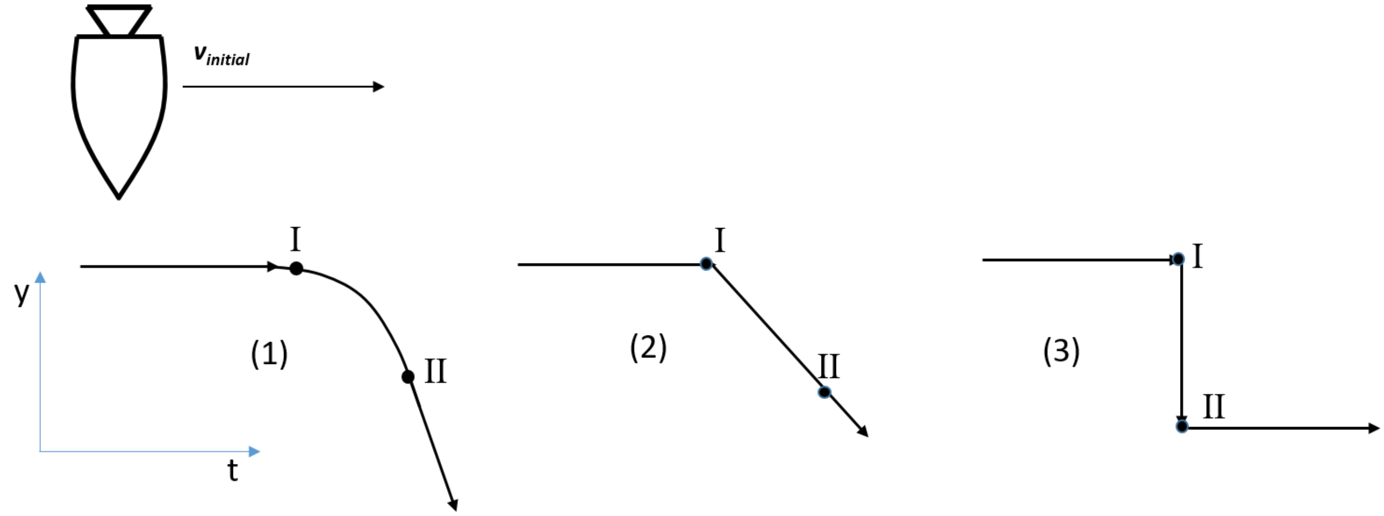
a. D_1= 18.4 m
b. D_1= 16.5 m
c. D_1= 28 m
d. D_1= 37.7 m
e. D_1= 33.1 m

13) After reaching the bottom of the ramp, the block slides onto the horizontal floor with the initial speed of 18 m/s. The coefficient of kinetic friction between the block and the floor μ_k=0.4. From the moment it reaches the floor, how much time does it take the block to stop?

a. t = 1.8 s
b. t = 4.6 s
c. t = 45 s
d. t = 24 s
e. t = 9.8 s

14) If the mass of the block in the above problem were doubled, the time required for the block to come to a complete stop would

a. increase.
b. stay the same.
c. decrease.



A rocket is drifting in deep space where gravitational forces are negligible. The rocket is initially drifting sideways (*x* direction) with its engine off as shown above. The engine, which generates a constant force in the -*y* direction, is then turned on (corresponding to point **I**) for 4 seconds, and then turned off again (point **II**).

15) Which of the diagrams above best represents the path of the of the rocket?

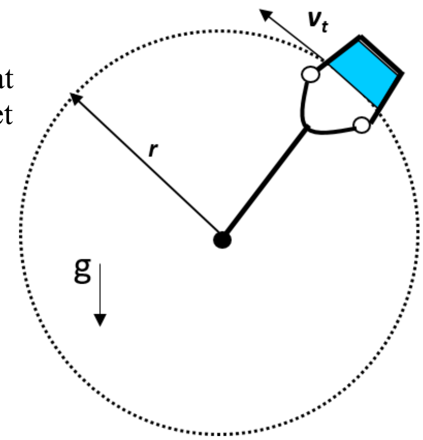
a. 1
b. 2
c. 3

16) An inclined plane makes an angle θ with respect to horizontal. A box sits at rest on the ramp, held in place only by friction. The magnitude of the frictional force exerted by the ramp on the box is:

a. $mg \sin\theta$
b. $\mu mg \cos\theta$
c. μmg

The next three questions pertain to the situation described below.

A metal bucket with mass 1.2 kg containing water of mass 7 kg is swung in a vertical circle of radius $r = 0.75$ m using a massless rope as shown in the figure. The tangential speed of the water bucket varies around the circle, but is such that at the top of the circle the tangential speed is just high enough to keep the bucket moving in a circular path.



17) The weight of the {bucket + water} and the tension in the rope when the bucket is at the top of the circle, T_{top}, form a Newton's 3rd Law action/reaction pair.

a. True
b. False

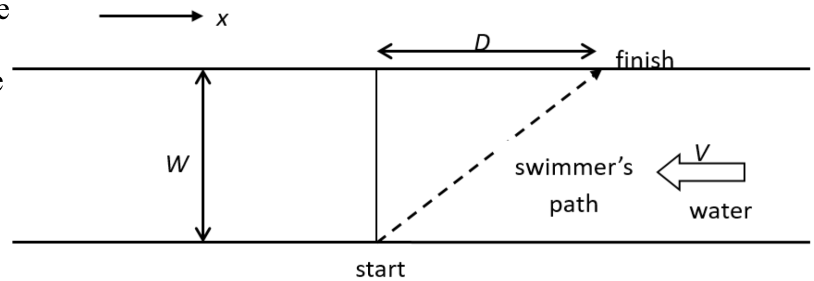
18) The minimum tangential speed, v_t of the bucket at the top of the circle is:

a. $v_t = 7.36$ m/s
b. $v_t = 3.84$ m/s
c. $v_t = 5.42$ m/s
d. $v_t = 3.13$ m/s
e. $v_t = 2.71$ m/s

19) What is the tension in the rope when the bucket is at its lowest point assuming its tangential velocity is 6.55 m/s.

a. $T = 469$ N
b. $T = 550$ N
c. $T = 80.4$ N
d. $T = 389$ N
e. $T = 80.4$ N

In a triathlon, a contestant swims in a straight line from start to finish in a time T. In order to do so, the contestant has to swim against the flow of the river which has a constant speed V relative to ground.

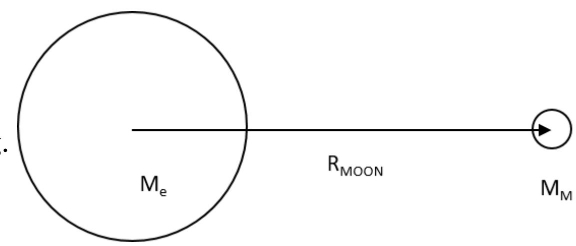


20) What is the x-component of the swimmer's velocity, v_x, with respect to the water? (Note the variables used in these equations D,T, V, and W are all positive.)

a. $v_x = \frac{D}{T} + V$
b. $v_x = \frac{W}{T} + V$
c. $v_x = \frac{D}{T} - V$
d. $v_x = \frac{D}{T}$
e. $v_x = \frac{W}{T} - V$

The next two questions pertain to the situation described below.

The moon has mass $M_M = 7.3 \times 10^{22}$ kg. It revolves around the Earth in a circular orbit of radius $R_{MOON} = 3.84 \times 10^8$ m with period $T = 27.3$ days. The Earth has mass $M_e = 6 \times 10^{24}$ kg. The gravitational constant is $G = 6.67 \times 10^{-11}$ Nm^2/kg^2



21) What is the magnitude of the force of the earth on the moon?

a. $|F_{\text{earth-moon}}| = 7.15 \times 10^{23}$ N
b. $|F_{\text{earth-moon}}| = 5.88 \times 10^{25}$ N
c. $|F_{\text{earth-moon}}| = 1.98 \times 10^{20}$ N

22) The speed of the moon relative to the center of the earth is V_{moon}. Suppose a satellite is in a circular orbit of radius R_{SAT} around the Earth and is moving with a speed relative to the center of the earth which is **less than** V_{moon}. Compare R_{SAT} to R_{MOON}

a. $R_{SAT} > R_{MOON}$
b. $R_{SAT} < R_{MOON}$
c. More information about the satellite is needed to answer this question.