

Problems will have partial credit. Show all work. Style, neatness, organization, and arrangement are important. Problems will be graded based on whether pictures, coordinate systems, free body diagrams, and basic equations are present. Do not do calculations in your head (unless you plan on turning it in too).

Multiple choice questions may have partial credit. Show work for them if at all possible.

1. A car can negotiate a level curve at 25 m/s. If the radius of curvature is halved, how fast can the car safely go?

- a) 17.7 m/s
- b) 25 m/s
- c) 35.4 m/s
- d) 45.1 m/s

25 (0.707)

$$a_{rad} = \frac{v^2}{R}$$

If R drops by $1/2$, then v^2 must drop by $1/2$
 $\Rightarrow v$ drops by $\sqrt{1/2} = 0.707$

2. A car rounding a racetrack at constant speed has

- a) non-zero radial and tangential components of acceleration
- b) zero radial and non-zero tangential components of acceleration
- c) non-zero radial and zero tangential components of acceleration
- d) zero acceleration



3. At the top of a ferris wheel revolving at constant speed, the net force on a passenger is

- a) sideways
- b) up
- c) down



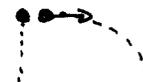
4. At the bottom of a ferris wheel revolving at constant speed, the net force on a passenger is

- a) sideways
- b) up
- c) down



5. Two balls are projected off a cliff. One is thrown horizontally, the other is released from rest and falls vertically. Which of the following statements is true?

- a) The ball that falls vertically hits the ground first.
- b) The ball that is projected horizontally hits the ground first.
- c) Both balls hit the ground at the same time.
- d) We cannot determine which ball hits the ground first unless we know the speed at which the first ball was projected horizontally



6. A ball is thrown upward with an initial velocity of 10 m/s. How long will it take to reach its maximum height?

- a) 1.02 s
- b) 0.51 s
- c) 1.42 s
- d) 2.84 s

Stops going up when $v_y = 0$

$$v_y(t) = v_{oy} + a_y t$$

$$0 = 10 + (-9.8)t$$

$$t = 1$$

7. A person standing at the edge of a cliff throws one ball straight up and another ball straight down at the same initial speed. Neglecting air resistance, the ball to hit the ground below the cliff with the greater speed is the one initially thrown

- a) upward
- b) downward
- c) neither of the above



8. You are throwing a ball straight up in the air. At the highest point, the ball's

- a) velocity and acceleration are zero.
- b) velocity is nonzero but its acceleration is zero
- c) acceleration is nonzero, but its velocity is zero
- d) velocity and acceleration are both nonzero

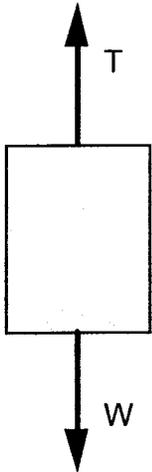
9. A package is dropped from a plane flying at constant velocity parallel to the ground. The package will:

- a) fall behind the plane
- b) remain directly below the plane until hitting the ground
- c) move ahead of the plane
- d) it depends on the speed of the plane

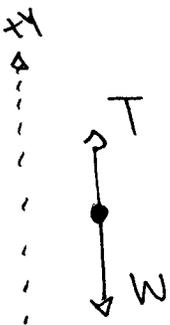
Neglects air resistance

10. Elevator Problems

Two main forces act on an elevator that moves up and down in an elevator shaft: the upward tension force T and the downward weight W . In the following situations, indicate which force has a greater magnitude or whether they are the same. (That is, write in $T > W$, $T = W$, or $T < W$)



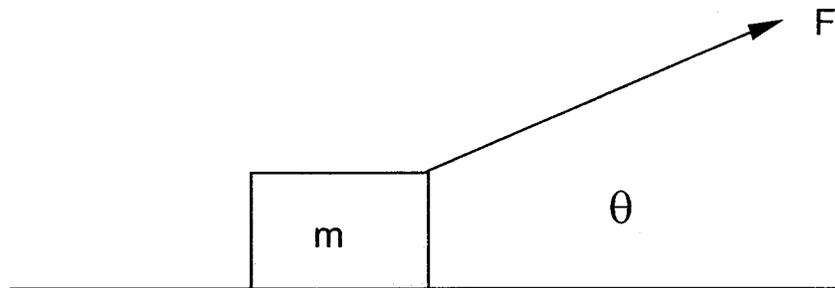
- | | | |
|---|----------------|------------------------------|
| a) The elevator hangs at rest on the ground floor. | $a = 0$ | <u>$T = W$</u> |
| b) The elevator's upward speed continually increases. | $a \uparrow$ | <u>$T > W$</u> |
| c) The elevator moves up at constant speed. | $a = 0$ | <u>$T = W$</u> |
| d) The elevator's upward speed continually decreases as it approaches the top floor. | $a \downarrow$ | <u>$T < W$</u> |
| e) After a stop at the top, the elevator's downward speed continually increases for a short time. | $a \downarrow$ | <u>$T < W$</u> |
| f) The elevator moves down at constant speed. | $a = 0$ | <u>$T = W$</u> |
| g) The elevator's downward speed decreases as it approaches the ground floor. | $a \uparrow$ | <u>$T > W$</u> |



$$m a_y = T - W$$

the direction of the acceleration vector determines whether T or W is larger

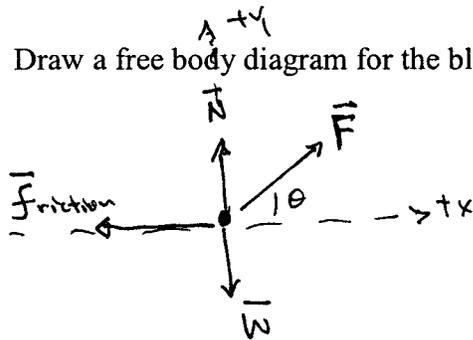
11. The box shown below is being dragged a distance L across a rough floor by application of a force F at an angle of θ with respect to the horizontal. The coefficient of kinetic friction is μ_k . The mass of the box is m . (The box remains in contact with the floor).



a) How many forces act upon the block?

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b) Draw a free body diagram for the block and indicate the direction of each force.



$$\begin{aligned}
 m a_x &= \sum F_x \text{'s} \\
 &= F \cos \theta - f \\
 &= F \cos \theta - \mu N
 \end{aligned}$$

$$\begin{aligned}
 m a_y &= \sum F_y \text{'s} \\
 m \cancel{a_y} &= N + F \sin \theta - mg \\
 0 &= N + F \sin \theta - mg \\
 N &= mg - F \sin \theta
 \end{aligned}$$

c) For each force, give the amount of work done by that force on the block as it slides across the floor. Express answers in terms of m , L , F , θ , μ and g .

Work done by $\vec{N} = \int_0^L \vec{N} \cdot d\vec{r} = 0$
 $\vec{N} \perp d\vec{r}$ because $\theta = 90^\circ$

Work done by $\vec{W} = \int_0^L \vec{W} \cdot d\vec{r} = 0$
 $\vec{W} \perp d\vec{r}$ because $\theta = 90^\circ$

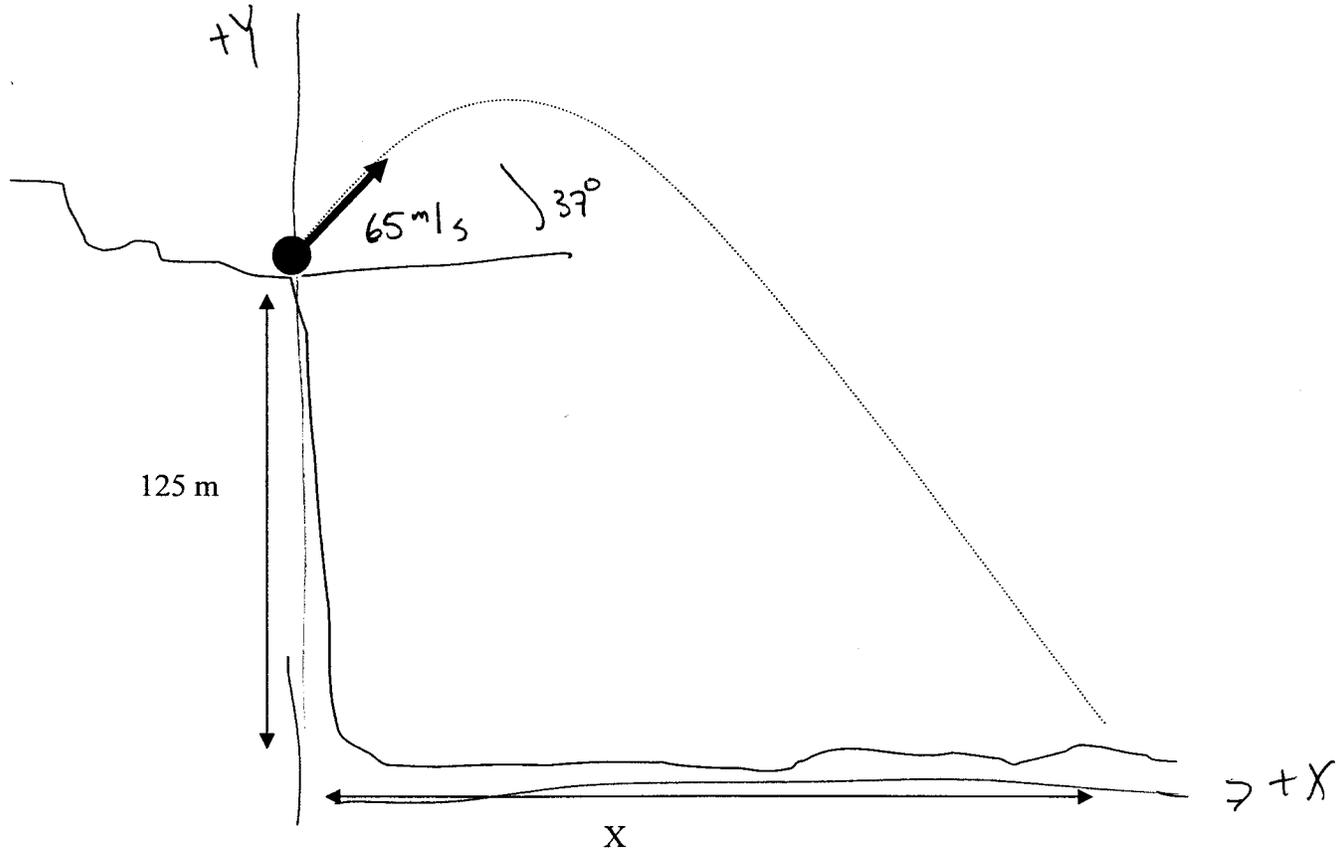
Work done by friction = $\int_0^L \vec{f} \cdot d\vec{r}$
 $= \mu N L \cos 180^\circ$
 $= \mu [mg - F \sin \theta] L \cos 180^\circ$
 $= -\mu [mg - F \sin \theta] L$

Work done by $\vec{F} = \int_0^L \vec{F} \cdot d\vec{r}$
 $= F L \cos \theta$
~~It's only the~~

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12. A projectile is shot from the edge of a cliff 125 m above ground level with an initial speed of 65 m/s at an angle of 37° from the horizontal, as shown in the figure.

- Determine the range X of the projectile as measured from the base of the cliff.
- Determine the velocity vector at the instant just before the projectile hits the ground.



The solution should be continued onto the next page. There's no need to try to cram it into the limited space below.

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$$x(t) = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$$

$$x_0 = 0$$

$$v_{0x} = 65 \cos 37^\circ = 51.9$$

$$a_x = 0$$

$$x(t) = 51.9t$$

$$y(t) = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$$

$$y_0 = 125$$

$$v_{0y} = 65 \sin 37^\circ = 39.1$$

$$a_y = -9.8$$

$$y(t) = 125 + 39.1t + \frac{1}{2}(-9.8)t^2$$

hits ground when $y=0$

$$0 = 125 + 39.1t - 4.9t^2$$

$$0 = -4.9t^2 + 39.1t + 125$$

$$t = \frac{-39.1 \pm \sqrt{(39.1)^2 - 4(-4.9)125}}{2(-4.9)}$$

$$t = \frac{-39.1 \pm 63.1}{-9.8} = \cancel{-24}, 10.4$$

$$x = 51.9(10.4)$$

$$= 540 \text{ m}$$

$$v_x(t) = v_{0x} + a_x t$$

$$v_{0x} = 51.9$$

$$a_x = 0$$

$$v_x(t) = 51.9$$

$$v_y(t) = v_{0y} + a_y t$$

$$v_{0y} = 39.1$$

$$a_y = -9.8$$

$$v_y(t) = 39.1 + (-9.8)t$$

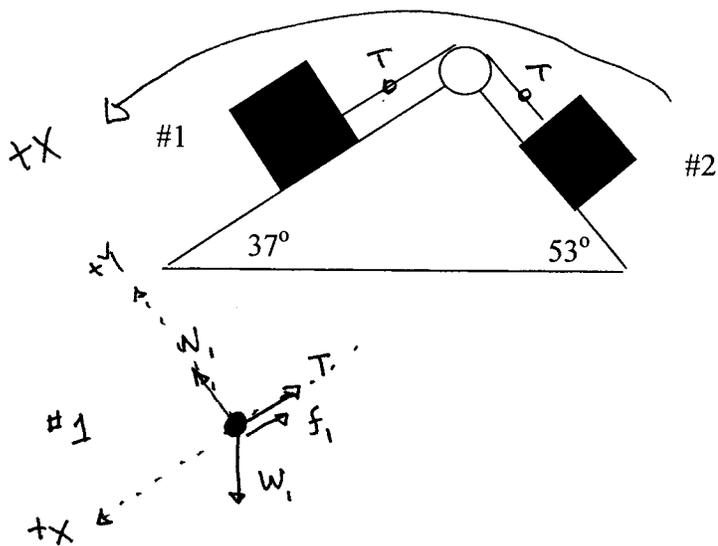
At $t = 10.4 \text{ sec}$

$$v_x = 51.9 \text{ m/s}$$

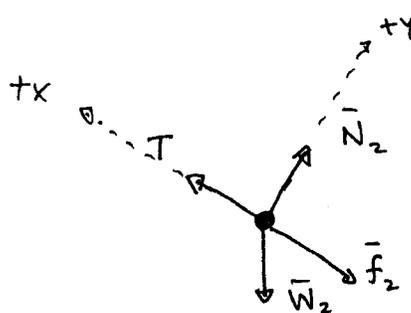
$$v_y = 39.1 + (-9.8)10.4$$
$$= -62.8 \text{ m/s}$$

13. Two masses are sliding on the double incline shown below. The masses are connected by a lightweight rope which passes over an ideal pulley. Block 1 is moving downhill while block 2 is moving uphill. The masses are $m_1 = 100 \text{ kg}$ and $m_2 = 50 \text{ kg}$. The coefficient of friction between each block and the surface is $\mu_k = 0.4$.

Find the acceleration of the masses.



Two objects



$$\begin{aligned}
 m_1 a_x &= \sum F_x \text{'s} \\
 &= m_1 g \sin 37^\circ - f_1 - T \\
 &= m_1 g \sin 37^\circ - \mu N_1 - T \\
 m_1 a_x &= m_1 g \sin 37^\circ - \mu m_1 g \cos 37^\circ - T
 \end{aligned}$$

$$\begin{aligned}
 m_1 a_y &= \sum F_y \text{'s} \\
 &= N_1 - m_1 g \cos 37^\circ \\
 N_1 &= m_1 g \cos 37^\circ
 \end{aligned}$$

$$\begin{aligned}
 m_2 a_x &= \sum F_x \text{'s} \\
 &= T - f_2 - m_2 g \sin 53^\circ \\
 &= T - \mu N_2 - m_2 g \sin 53^\circ \\
 m_2 a_x &= T - \mu m_2 g \cos 53^\circ - m_2 g \sin 53^\circ
 \end{aligned}$$

$$\begin{aligned}
 m_2 a_y &= \sum F_y \text{'s} \\
 &= N_2 - m_2 g \cos 53^\circ \\
 N_2 &= m_2 g \cos 53^\circ
 \end{aligned}$$

The quickest way to get expression for acceleration is to add the two equations

$$\begin{aligned}
 (m_1 + m_2) a_x &= m_1 g \sin 37^\circ - \mu m_1 g \cos 37^\circ - \mu m_2 g \cos 53^\circ - m_2 g \sin 53^\circ \\
 (m_1 + m_2) a_x &= m_1 g [\sin 37^\circ - \mu \cos 37^\circ] - m_2 g [\mu \cos 53^\circ + \sin 53^\circ]
 \end{aligned}$$

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