Name_______________________________

Section_______________

1. (10 POINTS)

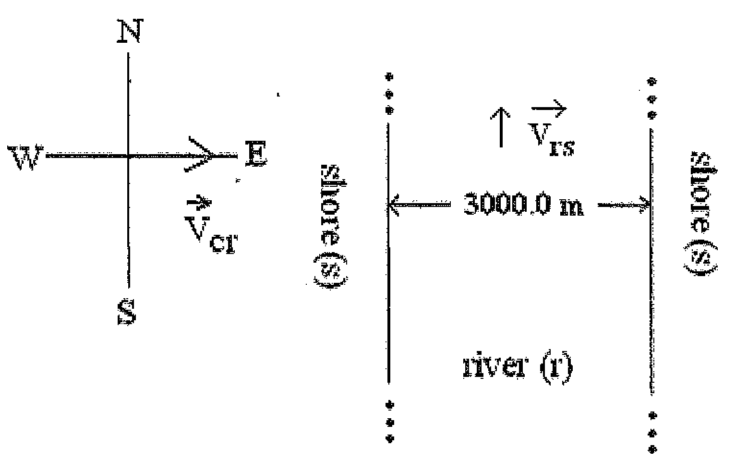
A cargo-boat is on the Mississippi river, which flows due NORTH with speed V_{rs} *relative to the shore.* River speed V_{rs} = 0.90 m/s. The cargo-boat has a velocity $\vec{V}_{cr}$ with magnitude 3.00 m/s and *direction* EAST *relative to the river.* Let the positive x direction be East and the positive y direction be North. See the schematic of the problem below. The velocity of the cargo-boat relative to the river is sketched in the diagram. SHOW ALL WORK!

Find:

(a) (4 points) the *magnitude* of the velocity $\vec{V}_{cs}$ of the cargo-boat *relative to the shore.*

(b) (4 points) the *direction* of velocity $\vec{V}_{cs}$ of the cargo-boat *relative to the shore.* Find this direction by computing the *angle* between the x axis and velocity $\vec{V}_{cs}$. In what quadrant does $\vec{V}_{cs}$ point? Make a careful sketch.

(c) (2 points) Suppose the river is 3,000.0 m wide. Suppose the cargo-boat starts on the western shore, i.e., left shore in the diagram. How long (in seconds) does it take the cargo-boat to cross the river? Convert your answer to hours.



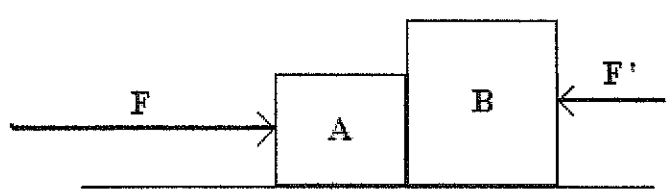
Name______________________________
Section_______________

2. (40 points) Furniture boxes A and B are in contact on a *frictionless* horizontal surface. Starting from rest, a mover applies a *rightward* horizontal force to Block A of magnitude F = 101.25 N. The block's masses are m_A = 4.00 kg, and m_B = 10.00 kg.

The moving occurs outdoors in Chicago, the "Windy City", and a heavy wind applies a *leftward* horizontal force to Block B of magnitude F' = 33.25 N. To most clearly show your thinking, try to use these and possibly other well established *symbols* until the last step before your numerical answer, which you should box.

For parts (a) and (b) *label* all vector components with symbols.

(a)(4 points) Draw a force diagram for Block A. Show all horizontal and vertical forces with labeled arrows.
(b)(4 points) Draw a force diagram for Block B. Show all horizontal and vertical forces with labeled arrows.
(c) (15 points) What is the magnitude F_{AB} of the force of contact on Box A due to Box B?
(d)(1 point) What is the magnitude F_{BA} of the force of contact on Box B due to Box A?
(e) (15 points) What is the common acceleration *a* (in m/s^2) of the two blocks?
(f) (3 points) What is the common velocity of the two blocks after 3.00 seconds?



Name_______________________________

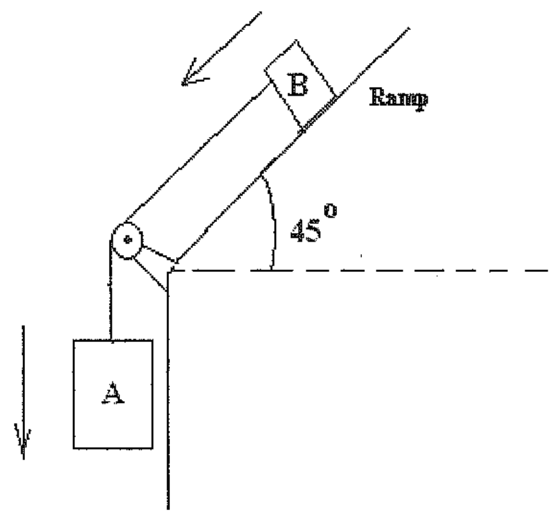
Section_______________

3. (40 points) In a Port of Oakland loading operation, 2 boxes are connected by a mass-less cable wrapped around a frictionless pulley. Neglect the cable's mass. For safety reasons, engineers designed the system so the downward acceleration of Box A is less than the acceleration of gravity g. Assume g = 9.80 m/s^2.

Box A, which carries overseas cargo, descends vertically. Box B, a counterweight, slides down an incline which makes an angle of 45 degrees with horizontal. The coefficient of kinetic friction between box B and the inclined surface is μ_k = 0.46, which corresponds to the aluminum-bronze alloy box on a steel surface incline. Show all work including force diagrams for each mass. Fully loaded, Box A's mass is 10.00 kg. Box B's mass is 5.00 kg.

(a) (25 points) What is the magnitude *a* (in m/s^2) of the common *acceleration* of the two boxes?

(b) (15 points) What is the magnitude T of the tension in the cable?



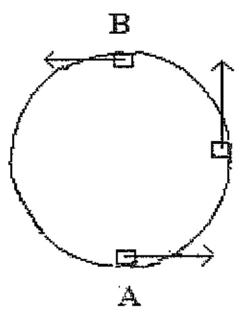
Name________________________________

Section_______________

4. (30 POINTS) A small car with mass 0.800 kg travels at *constant speed* V on the *inside* of a track that is a VERTICAL CIRCLE with radius R= 5.00 m. Assume the normal force magnitude N exerted by the track on the car when it is at the *top* of the track (point B) is 6.00 N. NOTE: Conservation of energy is *not* needed for this problem, based purely on *circular dynamics.* Assume g = 9.80 m/s^2.

(a) (15) What is the magnitude N of the normal force of the track on the car when it is at the bottom (point A) ?

(b) (15 points) What is the magnitude N of the normal force of the track on the block when it reaches point C at the *end of the horizontal diameter* ?



Name_______________________________

Section______________

5. (30 points) A 2.00-kg block starts from rest at point 1 on a *smooth* incline making a 30-degree angle with the horizontal. See diagram. The block slides downward along the frictionless incline a distance L = 3.00 m to point 2. The block then moves horizontally on a *rough* surface toward an *un-deformed* spring parallel to the horizontal. *Before colliding with the spring*, the block moves distance D = 2.00 m along horizontal to point 3. Assume g = 9.80 m/s^2.

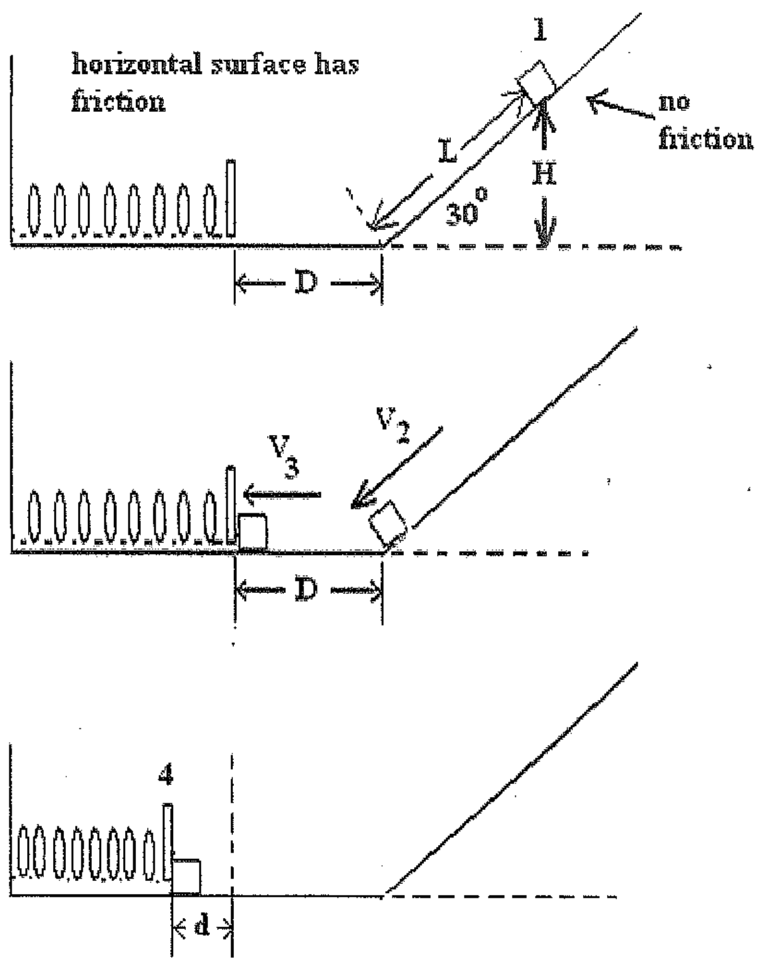
Assume the coefficient of kinetic friction between the block and *horizontal* surface is μ_k = 0.600, for aluminum on a "mild steel" surface. The spring's force constant is k = 125.00 N/m. *You may neglect the block's dimensions. The diagram may not be of exactly the same scale as your calculated results. Examine the diagram carefully as you do each part below.*

(a) (2 points) At point 1, what is the block's initial vertical height H above the horizontal surface?

(b) (3 points) What is the block's speed V_2 at the incline's bottom *just before starting to move horizontally?*

(c) (12 points) What is the block's speed V_3 *just before* colliding with the spring?

(d) (12 points) What is the spring's *maximum* compression distance d when the block momentarily comes to rest at point 4?



Name________________________________

Section______________

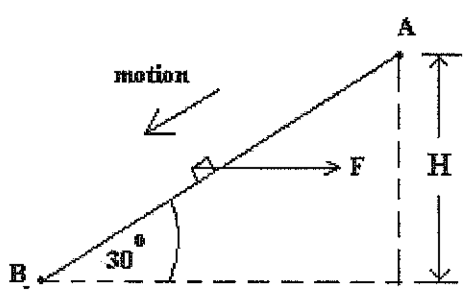
6. (30 points) Pushing a Cat Part III.

Your Cat "Ms." (mass m = 12.00 kg, represented by box below) slides *down* a ramp from the top at point A. The ramp is *2.00 m long* and inclined upward at 30.0 degrees with the horizontal. At point A (the top) the cat starts with running speed 2.40 m/s directed downward *along the incline.* Since you want to limit the big cat's speed at the bottom of the ramp, you push her with a steady *horizontal* force of magnitude F = 26.00 (N). As she moves down the incline, a constant frictional force of magnitude f = 7.00 N also acts on the cat.

See below diagram showing the cat moving downward along the incline; the distance between points A and B is 2.00 m. Assume g = 9.80 m/s^2.

For full credit, you must use energy related methods in Chapter 6 or 7 for part (e). Otherwise you could lose points. However, with some penalty, you are free to use other methods if you are uncomfortable with energy related techniques.

(a) (2 points) What is the cat's initial vertical height H?
(b) (3 points) Is work W_F done by horizontal force of magnitude F positive or negative? Explain clearly using words and mathematical arguments.
(c) (12 points) What is the numerical value of the work W_F (in Joules) done by horizontal force of magnitude F?
(d) (3 points)) Is work W_{fk} done by friction positive or negative? Explain clearly using words and mathematical arguments.
(e) (12 points) What is the cat's speed when she reaches the bottom (point B)?



Name______________________________

Section______________

Short answers using scantron: If you make a mistake, erase *carefully*. The best policy is to circle your answers before you mark the scantron

1. Is it possible for the net force on an object to be in the *opposite* direction as the velocity? Yes or No. (a) Yes (b) No

2. Mass is a measure of how difficult it is to change the velocity of an object. True or False. (a) True (b) False

3. In the *absence* of a net force, a moving object will (a) stop immediately (b) slow down and eventually some to a stop (c) move faster and faster (d) move with constant velocity

4. An object moves along a *rough* horizontal surface to the left. The friction force points (a) right (b) vertically upward in the same direction as the normal force. (c) left

5. The mass of Jupiter is about 1/1000 of the mass of the Sun. Therefore the magnitude of the force exerted by the Sun on Jupiter is about 1000 times the magnitude of the force exerted by Jupiter on the Sun. True or False. (a) True (b) False

6. Kinetic energy can be negative. True or False. (a) True (b) False

7. The quantity $\frac{1}{2}kx^2$ is (a) the kinetic energy of an object (b) the potential energy of a spring (c) the gravitational potential energy of an object (d) the power supplied to an object by a force.

8. If g is 1.6 m/s^2, the quantity mgy is (a) the kinetic energy of an object (b) the potential energy of a spring (c) the gravitational potential energy of an object near the Earth's surface (d) the gravitational potential energy of an object near the Moon's surface (e) the power supplied to an object by a force.

9. The dot product $\vec{F}\cdot\vec{v}$ of the force and the velocity is (a) the kinetic energy of an object (b) the potential energy of a spring (c) the gravitational potential energy of an object (d) the instantaneous power supplied to an object by the force

Name______________________________

Section_______________

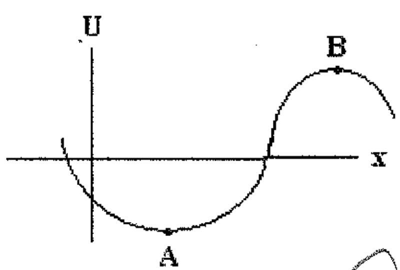
10. What we have learned so far is that the work done W_{fk} by a friction force is negative. True or False. (a) True (b) False

11. What we have learned so far is that heat is the negative of the work of friction i.e. heat = - W_{fk} . True or False. (a) True (b) False

12. A ball drops some distance and loses 40 J of gravitational potential energy. Do *not* ignore air resistance (air friction). How much kinetic energy did the ball gain ? (a) more than 40 J (b) exactly 40 J (c) less than 40 J

13. A ball drops some distance and loses 40 J of gravitational potential energy. *Ignore* air resistance(air friction) . How much kinetic energy did the ball gain ? (a) more than 40 J (b) exactly 40 J (c) less than 40 J

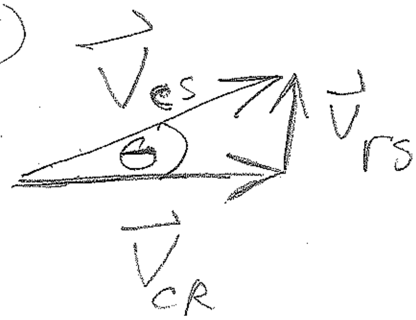
14. A potential energy function is shown below. It is only a function of x.



Point A is a position of (a) stable equilibrium (b) unstable equilibrium

Test 2 solutions CH 3, 4, 5, 6, 7.

(1.)



(a.) $V_{es}^2 = V_{cr}^2 + V_{rs}^2$

$= (3.00^2 + 0.90^2)\,\frac{m^2}{s^2}$

$= (9.00 + 0.81)\,\frac{m^2}{s^2}$

$= 9.81\,\frac{m^2}{s^2} \rightarrow V_{cs} =$

$V_{es} = \sqrt{9.81}\,\frac{m}{s} = 3.13\,m/s$

(b.) $\tan\theta = \frac{0.90}{3.00} \rightarrow \theta = \boxed{16^\circ}$

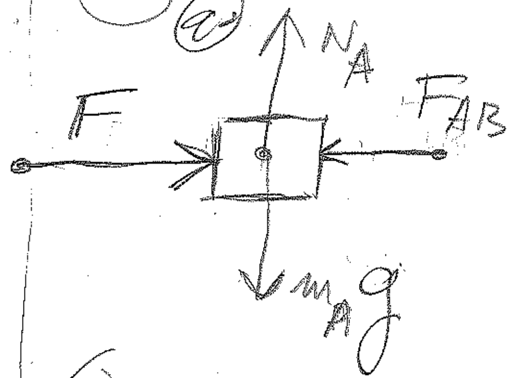
(c.) $V_{cr} = \frac{3000\,m}{\Delta t} = 3\,\frac{m}{s}$

$\Delta t = \frac{3000\,m}{3\,m/s} = 1000\,(s)$

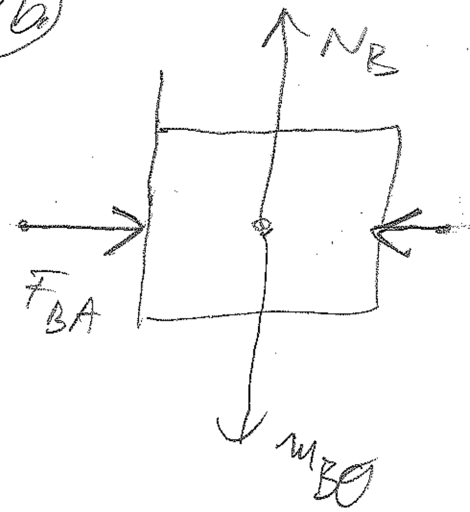
$1000\,s \times \frac{1}{3600}\,\frac{h}{s} = \boxed{0.278\,h}$

≈ 30 minutes

(2.) (a.)



(b.)



(c.) $m_A a = F - F_{AB}$

$m_B a = F_{BA} - F'$

$a = \frac{F - F'}{(m_A + m_B)}$

$a = \frac{68.00\,(N)}{14.00\,kg} = \boxed{4.857\,\frac{m}{s^2}}$

THUS: $m_A \cdot (4.8571\,\frac{m}{s^2}) = 101.25 - F_{AB}$

$\Rightarrow F_{AB} = 101.25 - (4.00)(4.8571)$

$= \boxed{81.8\,(N)}$

2.

d. $F_{BA} = F_{AB} = 81.8\,(N)$

e. $a = 4.857\ \frac{m}{s^2}$

f. $v = a \cdot t$

$= (4.857\underline{1})(3.00)\ \frac{m}{s}$

$= 14.\underline{5}713 = 14.6\ \frac{m}{s}$

3. A| $m_A a = m_A g - T$

B| $m_B a = m_B g \sin 45 + T - f_K$,

where $f_K = \mu_K m_B g \cos 45$

ADD equations, cancel T:

$$a = \frac{m_A g + m_B g \sin 45 - f_K}{(m_A + m_B)}$$

$$a = \frac{g(m_A + m_B \sin 45) - \mu_K m_B g \cos 45}{(m_A + m_B)}$$

$$a = \frac{(9.80)(10.00 + 5.00 \cdot 0.707) - (0.46)(5.00)(9.80)(0.707)}{15.00\,kg}$$

$$a = \frac{132.643 - 15.936}{15.00}$$

$$= \frac{116.70722}{15.00}$$

$= 7.7\underline{8}\ m/s^2$

b. use A|, easiest:

$T = m_A(g - a)$

$T = (10.00)(9.8\underline{0} - 7.78\underline{0}5)$

$= 20.\underline{1}95\,(N)$

$= 20.2\,(N)$

4. Given: AT B

a. $\frac{mv^2}{R} = N_B + mg$

$\frac{mv^2}{R} = 6.00 + (0.800)(9.80)$

$\frac{mv^2}{R} = 13.84$

AT A| $\frac{mv^2}{R} = N - mg$

$N_A = 13.84 + (0.800)(9.80)$

$= 21.6\underline{8}\,(N)$

b. AT C| $\frac{mv^2}{R} = N$

$N_C = 13.84\,(N)$

(4.)

NOTE: $N_c = \dfrac{N_A + N_B}{2}$

$N_c = \dfrac{21.68 + 6}{2} = \boxed{13.84}$

(5.) (a.) $H = L \cdot \sin 30 =$

$= (3.00)(\tfrac{1}{2}) = 1.50\,m$

(b.) $\Delta KE = W_g$ (CH6)

$\tfrac{1}{2}mv^2 = W_g$

$\tfrac{1}{2}mv_2^2 = +mgH$

$v_2^2 = 2gH$

$v_2 = \sqrt{2(9.80)(1.50)}$

$= 5.422\ m/s$

(c.) $\Delta KE = W_{f_k}$ (CH6)

$\tfrac{1}{2}mv_3^2 - \tfrac{1}{2}mv_2^2 = -f_k \cdot D$

$\tfrac{1}{2}mv_3^2 - \tfrac{1}{2}mv_2^2 = -\mu_k mg \cdot D$

$V_3^2 = V_2^2 - \mu_k \cdot g \cdot D$

$V_3^2 = (5.422)^2 - (0.600)(9.80)(2.00)$

$= 29.398 - 11.76 = 17.638$

$V_3 = 4.19976$

$= 4.20\ m/s < V_2$

(c) conservation of Energy: (CH7)

$\tfrac{1}{2}mv_3^2 = \tfrac{1}{2}Kd^2 + \text{Heat}$

$\tfrac{1}{2}mv_3^2 = \tfrac{1}{2}Kd^2 + \mu_k \cdot mg \cdot d$

$\tfrac{1}{2}(2)(17.638)$

$= \tfrac{1}{2}(125)d^2$

$+ (0.600)(2.00)(9.80)d$

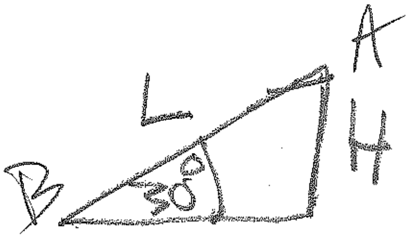
$\Rightarrow 125d^2 + 23.52d - 35.276$

$d = \dfrac{-23.52 \pm \sqrt{(23.52)^2 + (4)(125)(35.276)}}{250}$

$d = \dfrac{-23.52 + 134.874}{250}$

$d = 0.45\ (m) = 45\ cm$

6.

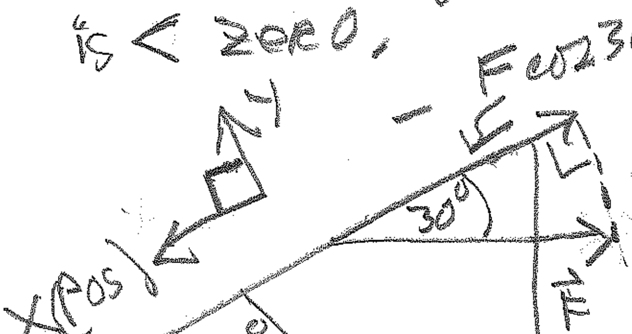


a. $H = L \cdot \sin 30$

$= \boxed{1.00\,m}$

b. $W_F < 0$

since $\vec{F}$-component along positive x-direction (downward along incline) is < zero.



c

$W_F = (-F\cos 30)\cdot L$

$W_F = (-26.00 \cdot [0.867]) \cdot (2.00)\,J$

$= -45.084 = -45.1\,(J)$

d $W_{f_k} = -f_k \cdot L < 0$

$W_{f_k} = -(7.00)(2.00)$

$= -14.00\,J$

e $\Delta KE = W_g + W_{f_k} + W_F$

$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = mgH + W_{f_k} + W_F$

note: $mgH = (12.00)(9.80)(1.00)$ Joules

$mgH = 117.6\,(J)$

$\frac{1}{2}mv_f^2 = \frac{1}{2}mv_i^2 + 117.6 - 14.00 - 45.084$

note: $\frac{1}{2}mv_i^2 = \frac{1}{2}(12.00)(2.40)^2 = 34.56\,J$

$\frac{1}{2}mv_f^2 = 34.56 + 117.6 - 14.00 - 45.084 = 93.076$

$v_f = \boxed{3.94\,m/s}$