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1. (36 POINTS)

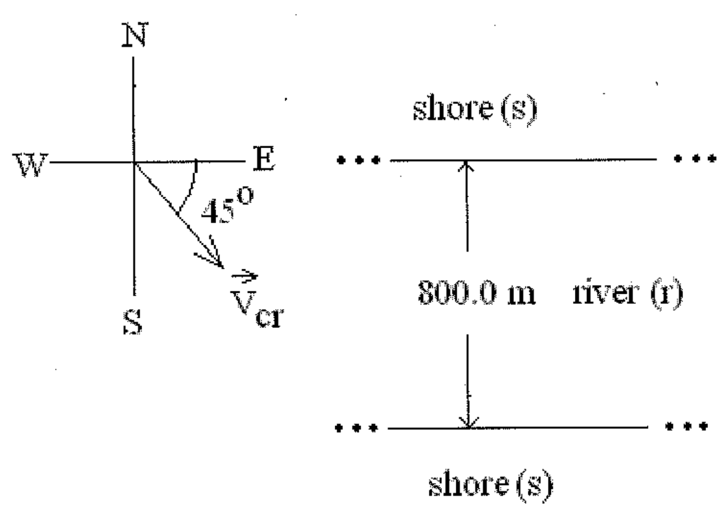
A canoe is on a river that is flowing due EAST with speed V_{rs} *relative to the shore.* River speed V_{rs} = 0.50 m/s. The canoe has a velocity $\vec{V}_{cr}$ with magnitude 0.40 m/s and *direction* southeast *relative to the river.* Let the positive x direction be East and the positive y direction be North. See the schematic of the problem below. The velocity of the canoe relative to the river is sketched in the diagram. SHOW ALL WORK!

Find:

(a) (16 points) the *magnitude* of the velocity $\vec{V}_{cs}$ of the canoe *relative to the shore.*

(b) (16 points) the *direction* of velocity $\vec{V}_{cs}$ of the canoe *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) (4 points) Suppose the river is 800 m wide. Suppose the canoe starts on the northern shore, i.e., upper shore, in the diagram. How long (in seconds) does it take the canoe to cross the river? Convert your answer to hours.



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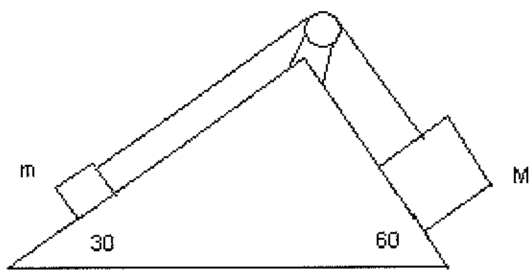
2. (36 POINTS)

Two blocks move on a *double* inclined plane. The blocks are connected by a string wrapped around a *frictionless* pulley of negligible mass compared to that of the blocks. Block masses $m = 3.00$ kg and $M =$ 20.0 kg. There is also *no friction* along the surfaces of the double plane. Assume g= 9.80 m/s^2. The angles shown are exact.



(a) (16) What is the magnitude of acceleration *a* of the blocks ?

(b) (16) What is the tension T in the string ?

(c) (4) Suppose the two blocks start their motion *from rest* at t = 0. What is the common speed v (in m/s) of the blocks when t = 2.00 seconds

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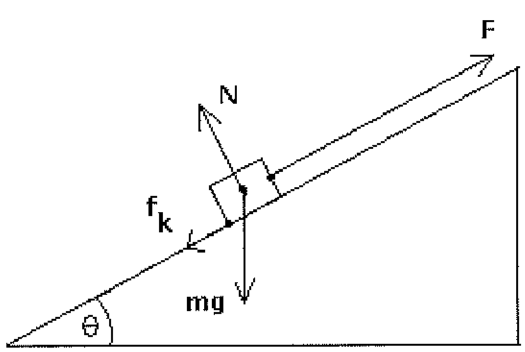
3. (37 points) On the Moon, student astronauts perform a physics experiment inside the laboratory of their parked space ship. A block of mass m is pulled upward along an inclined plane under the influence of an *applied force* of magnitude F and direction parallel to the surface. See diagram below. F = 2.000 x10^2 (N) (about 200 (N)). The incline makes an angle of exactly 30 degrees with the horizontal. Mass m = 5.00 kg.

As the box moves up the incline, a friction force of magnitude f_k points opposite the motion. The kinetic friction force magnitude f_k = 4.00 (N). The gravitational force and the normal force are also shown schematically in the diagram below. On the Moon, assume the value of the gravitational acceleration g = 1.60 m/s^2.

(a) (30 points) Assuming the positive x-direction is upward along the incline, ***what is the acceleration a_x along the incline?***

(b) (7 points) What is the coefficient of kinetic friction μ_k between the box and incline?



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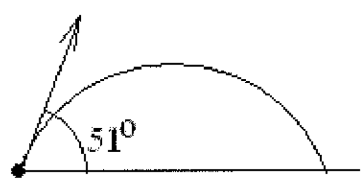
4. (14 points) A place kicker kicks a football from a point a *horizontal* distance of 37.00 m from the goal. When kicked (at t = 0), the ball leaves the ground (at y = 0) with speed 21.00 m/s at an angle of exactly 51 degrees *with the horizontal.* Below is a schematic of the ball's complete path and the ball at the *start* of its motion. The goal location is *horizontally* 37.00 m to the right of the ball shown by the dot • . Assume g = 9.80 m/s^2.

(a) (4 points) What is the vertical height h of the ball when it passes over the goal?

(b) (4 points) What is the y-component of velocity V_y when the ball passes over the goal?

(c) (2 points) What is the x-component of velocity V_x when the ball passes over the goal? Explain.

(d) (4 points) Using the Pythagorean Theorem, find the *speed* of the ball when it passes over the goal.



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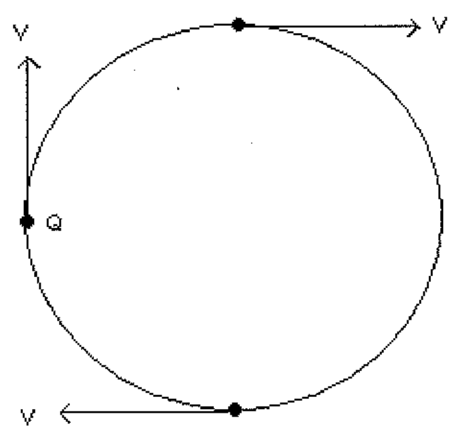
5. (10 points)

A 0.385-kg rock is swung in a vertical circular path on a <u>string</u> that is 0.480 m long. Assume the speed v of the rock is 3.90 m/s. Three points on the circular path are shown: the top, the bottom and point Q at the end of a *horizontal*, radial line segment. Assume g = 9.80 m/s^2.



What is,

(a) (5 points) the magnitude a_C of the centripetal acceleration at point Q?

(b) (5 points) the direction of the centripetal acceleration at point Q? Draw an arrow whose tip points in the correct direction.

(c) EXTRA CREDIT (3 points) What is the tension magnitude T in the string at the bottom?

(d) EXTRA CREDIT (3 points) What is the tension magnitude T at the top?

(e) EXTRA CREDIT (3 points) What is the tension magnitude T at point Q where the rock is in a <u>horizontal</u> position relative to the center.

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Short Answers. Multiple choice: Mark your scantron with a #2 pencil.

1. The horizontal component of the velocity of a projectile remains constant during the entire trajectory of the projectile. Neglect air resistance. True or False. (a) True (b) False

2. The vertical component of the velocity of a projectile remains constant during the entire trajectory of the projectile. Neglect air resistance. (a) True (b) False

3. A projectile is launched from ground level with a certain speed. For any horizontal range less than the maximum horizontal range, there are two possible launch angles that give the same horizontal range. (a) True (b) False

4. A projectile is launched from ground level with a certain speed. For the maximum horizontal range, the launch angle is (a) 90 degrees (b) 45 degrees (c) 0 degrees

5. The acceleration of a projectile remains constant during the entire trajectory of the projectile. Neglect air resistance. (a) True (b) False

6. Mary needs to row her boat across a river that is flowing East at 4.0 m/s. When she starts out at the shore, her initial aim direction is North. Mary can row with a speed of 3.0 m/s relative to the water.

What is the boat's speed relative to the shore? (a) 7.0 m/s (b) 1.0 m/s (c) 5.0 m/s

7. In the previous problem, what angle does the boat's velocity make relative to the Northward direction as Mary rows? (a) 37 degrees (b) 53 degrees (c) 60 degrees (d) 30 degrees

8. A satellite moves in a circular orbit at constant speed. The satellite's acceleration is zero. (a) True (b) False

9. Force is a vector quantity. True or False. (a) True (b) False

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10. Mass is a vector quantity. True or false. (a) True (b) False

11. If an object is moving, there must be a net force on it. (a) True (b) False

12. The net force on an object is always in the same direction as the velocity. True or False. (a) True (b) False

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

14. 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

15. Neglect air resistance. A ball is thrown upward. When it reaches its maximum height, the net force on the object is zero. True or False. (a) True (b) False

16. A ball is thrown upward in the air. Neglect air resistance. When it is rising after being thrown and reaches half of its maximum height, the net force magnitude acting on it is (a) equal to its weight (b) less than its weight (c) zero

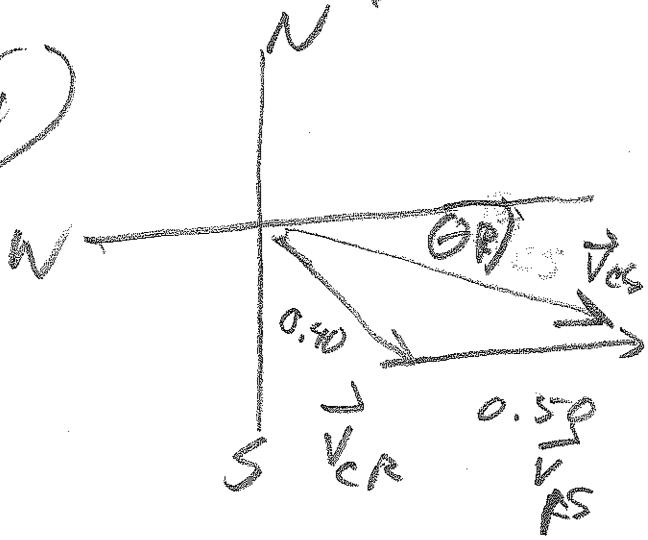
17. An object moves along a *rough* horizontal surface to the right. The friction force points (a) right (b) vertically upward in the same direction as the normal force. (c) left

18. From Newton's Third Law, action-reaction forces are (a) equal in magnitude and point in the same direction (b) equal in magnitude and point in opposite directions. (c)) unequal in magnitude and point in opposite directions

19. The mass of the Moon is about 1/80 of the mass of the Earth. Therefore the magnitude of the force exerted by the Earth on the Moon is about 80 times the magnitude of the force exerted by the Moon on Earth. True or False. (a) True (b) False

Test 2 Solutions

(1)



$V_{CS_x} = +(0.40)\cos 45 + 0.50$

$= 0.78$

$V_{CS_y} = -0.40\sin 45 + 0$

$= -0.283$

$V_{CS} = \sqrt{(0.78)^2 + (0.283)^2}$

$= \sqrt{0.6884}$

$= 0.830 \ m/s$

$\tan\theta_R = \dfrac{|-0.283|}{0.78}$

$= 0.3628$

$\theta_R = 19.94°$

QUADRANT IV.

$\Delta t = \dfrac{800 \ m}{(0.830 \frac{m}{s}) \sin 19.94}$

$= 2826.3 \ (s)$

$= 0.785$ hour

(2)

$ma = T - mg\sin 30$

$Ma = Mg\sin 60 - T$

$a = \dfrac{Mg\sin 60 - mg\sin 30}{M + m}$

$= \dfrac{(20.0)(9.8\bar{0})(0.867) - (3.00)(9.80)\frac{1}{2}}{23.0}$

$= \dfrac{169.932 - 14.7}{23.0}$

$= \dfrac{155.232}{23.0} = \boxed{6.75 \frac{m}{s^2}}$

2 (b)

$(3.00)(6.75)$

$= T - (3.00)(9.8)\frac{1}{2}$

$\Rightarrow$

$T = (3.00)(6.75) + 14.7$

$= 34.95$ (N)

(c)

$v = at$ [from (b) 2]

$= (6.75 \frac{m}{s^2})(2.00)$

$= 13.5 \frac{m}{s}$

(3)

$ma = F - mg\sin 30 - f_K$

$(5)a = 200.0 - (5)(1.6)\frac{1}{2} - 4.00$

$5a = 200.0 - 4.00 - 4.00$

$5a = 192.0$

$a = 38.4 \, m/s^2$

$f_K = \mu N$

$N = mg\cos 30$

$4.0 = \mu(5)(1.6)(0.867)$

$\mu = \frac{4.0}{(5)(1.6)(0.867)}$

$= 0.577$

---

(4) $\Delta t = \frac{37.00}{(21)\cos 51}$

$= 2.80$ (s)

$h =$

$(21)(\sin 51)(2.80) - \frac{1}{2}(9.8)(2.80)^2$

$= 45.696 - 38.416$

$= 7.3$ (m)

(b) $v_y = (21)\sin 51 - (9.8)(2.8)$

$= -11 \, m/s$

(4)

(c)

$V_x = (21)\cos 51$

$= 13.21\ m/s$

(d)

$V = \sqrt{13.21^2 + 11^2}$

$= 17.2\ m/s$

---

(5) (a) $a_c = \frac{v^2}{R}$

$= \frac{(3.9)^2}{0.480} = 31.7\ \frac{m}{s^2}$

(b) $\longrightarrow$

(c)

Bottom $\frac{mv^2}{R} = T - mg$

$T = mg + \frac{mv^2}{R}$

$= m\left(g + \frac{v^2}{R}\right)$

$= (0.385)(9.8 + 31.7)$

$= 15.98\ (N)$

(d)

TOP $\frac{mv^2}{R} = T + mg$

$T = \frac{mv^2}{R} - mg$

$= (0.385)\left(\frac{v^2}{R} - 9.8\right)$

$= (0.385)(31.7 - 9.8)$

$= 8.43\ (N)$

(e)

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

$$T = (0.385)(31.7)$$

$$= 12.20 (N)$$

1 a

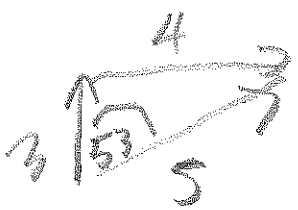
2 b

3 a

4 a

5. a

6 c

7 

b

8 b

9 a

10 b

11 b

12 b

13 a

14 d

15 b

16 a

17 c

18 b

19 b