

CONSERVATION OF MASS

1. CONCORDIA, WHO WEIGHS 96 lbs. ON EARTH, TAKES A LUNAR HOLIDAY, WHERE THE ACCELERATION DUE TO GRAVITY IS 5.48 ft/sec^2 . FIND HER:

- A) MASS (3 SLUGS) B) LUNAR WEIGHT (16.44 lbs)
 C) WHAT TOOL IS USED TO MEASURE EACH?

MOMENTUM AND NEWTON'S SECOND LAW

1. CALCULATE THE MOMENTUM FOR THE FOLLOWING:

- A) A .02 KG ARROW ZOOMING AT 140 m/sec.
 B) A 256 lb OSTRICH TROTGING AT 50 ft/sec.
 C) A 70 KG SPRINTER RUNNING 400 m IN 50 SEC.
 D) A 1280 lb HORSE GALLOPING 6600 ft IN TWO MINUTES.
 (2.8 km/s, 400 SLUGS ft/s, 560, 2200)

2. GREG'S 1250 KG RED PORSCHE ACCELERATES UNIFORMLY FROM 10 m/s TO 50 m/s IN EIGHT SECONDS, FIND HIS:

- A) INITIAL MOMENTUM B) FINAL MOMENTUM
 C) AVERAGE MOMENTUM D) FORCE OF THE ENGINE
 (12500, 62500, 37500, 6250)

3. KATHERINE'S 1800 KG METALLIC GREEN BMW USES A BRAKING FORCE OF 2700 N TO SLOW FROM 46 m/s FOR 14 SECONDS. FIND HER FINAL VELOCITY. (25)

4. A 768,000 lb BOEING 747, WHOSE ENGINES CAN SUPPLY A THRUST OF 198,000 lbs, IS FLYING HORIZONTALLY AT 540 MILES/HR, WHERE 1 MILE = 5280 FT. FIND THE TIME FOR THE JET TO ACQUIRE THIS SPEED IF IT STARTED FROM REST. (96 SEC.)

5. NOLAN RYAN PITCHES A .15 KG BASEBALL AT 45 m/s TO THE LEFT. WOODS HITS THE HORSEHIDE BACK TO THE RIGHT AT 65 m/s. THE BALL WAS IN CONTACT

WITH THE LOUISVILLE SLUGGER FOR .0012 SEC. FIND THE FORCE EXERTED ON: A) THE BALL BY THE BAT. B) THE BAT BY THE BALL. (13750, -13750 N)

6. NADYA DROPS A .6 KG BASKETBALL FROM THE ROOF OF SYMPHONY HALL, WHICH IS 125 m TALL. THE LEATHER ORB, WHICH IS IN CONTACT WITH THE GROUND FOR .02 SECONDS, REBOUNDS STRAIGHT BACK UP TO A HEIGHT OF 45 m. FIND: A) THE VELOCITY WITH WHICH IT HIT THE GROUND B) THE VELOCITY WITH WHICH IT LEFT THE GROUND C) THE FORCE EXERTED ON THE BALL BY THE GROUND. (-50, 30, 2400)

7. ALEX'S 16" GUN, WHOSE BARREL IS 30' LONG, FIRES A 2496 lb PROJECTILE AT A MUZZLE VELOCITY OF 2000 ft/sec. FIND THE FORCE EXERTED ON THE PROJECTILE WHILE IT IS IN THE BARREL. (5.2×10^6 lbs)

8. A FIRE HOSE, SPRAYING WATER AT 18 m/s, HAS A RECOIL FORCE OF 396 N. FIND THE MASS OF WATER SUPPLIED BY THE HOSE IN ONE MINUTE. (1320 kg)

9. A MACHINE GUN, WHICH FIRES .075 KG BULLETS AT 560 m/sec, HAS A RECOIL FORCE OF 28 N. FIND THE NUMBER OF BULLETS SHOT PER MINUTE. (40)

10. A 1200 KG SPACE PROBE ACCELERATES BY THROWING EXHAUST BACKWARDS AT 300 m/s. THE EXHAUST IN ONE SECOND HAS A MASS OF 18 KG. FIND: A) F_{THRUST} AND B) INITIAL ACCELERATION. (5400, 4.5)

11. A .8 KG HOCKEY STICK IS LYING ON FRICTIONLESS ICE. SHERI KICKS ONE END OF THE STICK WITH A FORCE OF 24 N. THE STICK, IN CONTACT WITH HER FOOT FOR .2 SEC, SPINS AS IT SLIDES. FIND THE ACCELERATION OF THE CENTER OF MASS WHEN: A) SHE KICKED IT B) AS IT ZOOMS AWAY. C) FIND ITS SPEED. (30, 0, 6)

INELASTIC COLLISIONS AND KINETIC ENERGY

1. SCOTT, WHOSE MASS IS 70 KG, IS SKIING AT 24 m/s ALONG HORIZONTAL, FRICTIONLESS SNOW. ALICE, $m = 50$ KG, IS STANDING ON THE SNOW WAITING WITH OPEN ARMS. SCOTT ZOOMS BY AND SWOOPS HER UP. FIND THEIR VELOCITY AS THEY CRUISE THROUGH THE WINTER WONDERLAND. (14 m/s)

2. GUMBY, WHOSE MASS IS 50 KG, IS ICE SKATING AT 20 m/s TO THE RIGHT ACROSS THE GREENLAND ICE SHEET. OH NO! A 450 KG POLAR BEAR SPIES GUMBY AND GIVES CHASE AT 60 m/s. THE BEAR HITS THE ICE AND SLIDES WILDLY AFTER HIS LUNCH. THE WHITE, FURRY BEAST HAS GUMBY IN HIS GRASP. FIND THEIR FINAL SPEED. (56 m/s)

3. THE 500 KG MASS OF FUR AND PUTTY IS ZOOMING AT 56 m/s TO THE RIGHT AS THE URSINE ALBINO PREPARES FOR LUNCH. POKEY TO THE RESCUE! CHARGE! THE 300 KG UNICORN COMES SLIDING AT 32 m/s IN THE OPPOSITE DIRECTION. A HEAD-ON COLLISION! POKEY ACCIDENTLY IMPALES POOR GUMBY AND NOW THE THREE SPEED ACROSS THE ICE. FIND THEIR FINAL VELOCITY. (23 m/s)

4. MR. HARVIE, $m = 60$ KG, IS STANDING ON A FRICTIONLESS, FROZEN LAKE WHILE CRADLING A 45 KG WISCONSIN BADGER IN HIS ARMS. MR. H. NOW FLINGS THE BADGER TO THE RIGHT AT 24 m/s. FIND:
 A) MR. H. FINAL VELOCITY (-18) B) THEIR LOCATIONS AFTER FIVE SECONDS, (-90, 0) (120, 0)
 C) HOW FAR THEY TRAVEL BEFORE THEY STOP.

5. A 40 kg PELICAN, CRUISING AT 30 m/s TO THE RIGHT, IS CHASING AN 8 kg FLYING FISH WHICH IS FLAPPING ALONG AT 24 m/s. THE AVIAN FISHERMAN OVERTAKES THE PISCINE AVIATOR AND SWALLOWS IT. FIND: A) THE INITIAL KINETIC ENERGY OF THE BIRD AND OF THE FISH.

B) THEIR FINAL VELOCITY C) THEIR FINAL KINETIC ENERGY D) THE AMOUNT OF K.E. TRANSFORMED INTO OTHER TYPES OF ENERGY DURING THE COLLISION.

(18000, 2304, 29, 20184, 120)

6. MEHERNAZ AND JENNIFER ARE BOTH DRIVING THEIR NEW BMW'S TO ASPEN FOR A SKI HOLIDAY. M'S CAR, WHOSE MASS IS 1200 kg, IS IN THE LEAD AND IS CRUISING AT 20 m/s. J'S CAR, $m = 1800$ kg, IS ZOOMING AT 36 m/s AS SHE TRIES TO CATCH UP.

ICE! THE TWO EUROPEAN IMPORTS ARE SLIDING FRICTIONLESSLY WHEN THE LARGE AUTO REAR-ENDS THE SMALLER ONE. AFTER THE COLLISION, JENNIFER'S LARGE BMW IS MOVING FORWARDS AT 28 m/s. FIND:

A) MEHERNAZ'S FINAL VELOCITY, WHICH SHE CHIVALROUSLY ACQUIRED TO SLOW DOWN JENNIFER. (32 m/s)

B) THE KINETIC ENERGY TRANSFORMED INTO OTHER FORMS OF ENERGY BY THE COLLISION, (86400 J)

7. THE STANLEY CUP! WAYNE GRETZKY, $m = 60$ kg, IS SKATING AT 32 m/s TO THE RIGHT. MARIO LEMIEUX, $m = 90$ kg, IS SKATING TO THE LEFT AT -12 m/s. THE TWO HOCKEY STARS COLLIDE HEAD-ON!

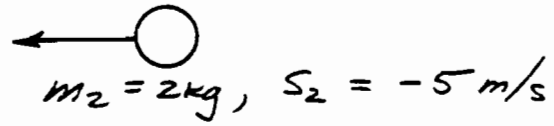
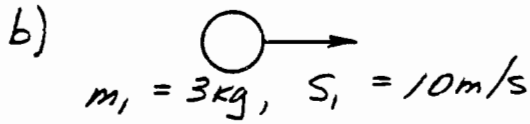
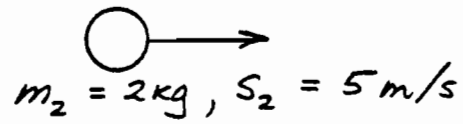
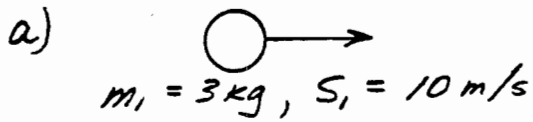
AFTER THE COLLISION, LEMIEUX IS MOVING BACKWARDS AT 6 m/s. FIND:

A) WAYNE'S FINAL VELOCITY. (5 m/s)

- B) FIND THE K.E. LOST IN THE COLLISION (34830 J)
8. ASTRONAUT STEPHANE, $m = 51 \text{ kg}$, IS FLOATING IN OUTER SPACE WHILE HOLDING A 17 kg TELESCOPE, WHICH IS NOT FOCUSING PROPERLY. IN DISGUST, STEPHANE FLINGS THE INSTRUMENT TO THE RIGHT AT 12 m/s . FIND: A) HIS FINAL VELOCITY (-4) B) THE TOTAL ENERGY SUPPLIED BY HIS MUSCLES. (1632)
9. JAMES BOND IS STUCK ON A FROZEN, FRICTIONLESS FINNISH LAKE. TO ESCAPE, BOND, WHOSE MASS IS 72 kg , FIRES SEVERAL BULLETS OUT OF HIS GUN TO THE RIGHT. EACH BULLET HAS A MASS OF $.05 \text{ kg}$ AND A MUZZLE VELOCITY OF 640 m/s . BOND RECOILS, TRAVELING BACK TO THE LEFT 68 m IN 17 SECONDS . FIND: A) THE NUMBER OF BULLETS WHICH HE FIRED. B) THE TOTAL ENERGY OF THE GUNPOWDER. (9, 92736)
10. AT CUYAMACA STATE PARK, A WILD 36 kg COUGAR WAS BITING THE VISITORS. THE ANIMAL RAN TO THE LEFT TOWARD THE RANGER, WHO FIRED SEVEN $.08 \text{ kg}$ BULLETS AT 900 m/s TO THE RIGHT TO STOP THE PANTHER. FIND: A) THE VELOCITY OF THE CATAMOUNT. B) THE TOTAL ENERGY DISSIPATED IN THE SAD ENCOUNTER OF THE MOUNTAIN LION AND THE BULLETS. (-14, 230328 JOULES)
11. AN 880 kg CANNON LOADED WITH A 20 kg BALL ROLLS ALONG A FRICTIONLESS TRACK AT 16 m/s . FIRE AWAY! AFTERWARDS THE CANNON'S VELOCITY IS ONLY 12 m/s . FIND: A) THE VELOCITY OF THE BALL B) THE TOTAL ENERGY FROM THE GUN POWDER. (192 m/s, 316800 JOULES)

ELASTIC COLLISIONS

1. WRITE THE TWO CONSERVATION EQUATIONS FOR THE COLLISIONS BELOW:




FORMULA:

$$V_1 = \left(\frac{m_1 - m_2}{m_1 + m_2} \right) S_1 + \left(\frac{2 m_2}{m_1 + m_2} \right) S_2$$

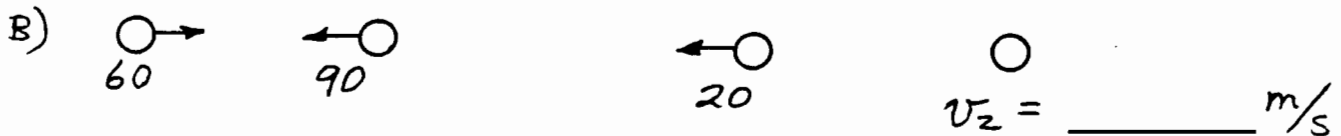
$$V_2 = \left(\frac{2 m_1}{m_1 + m_2} \right) S_1 + \left(\frac{m_2 - m_1}{m_1 + m_2} \right) S_2$$

ANSWER TO 1a: $(3)(10) + (2)(5) = 3V_1 + 2V_2$
 $\frac{1}{2}(3)(10)^2 + \frac{1}{2}(2)(5)^2 = \frac{1}{2}(3)V_1^2 + \frac{1}{2}(2)V_2^2$

2. CALCULATE THE FINAL VELOCITIES OF THE SPHERES IN PROBLEM 1a. (6 m/s, 11 m/s)

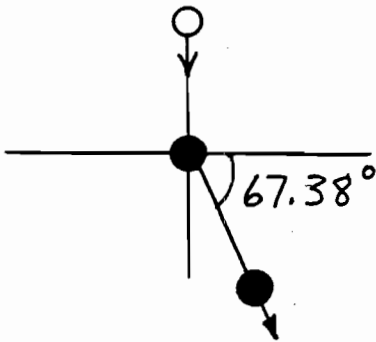
3. APPROXIMATE THE FINAL VELOCITY FOR THE CANNON BALL AND FOR THE B.B. $S_1 = 120 \text{ m/s}$ $S_2 = -80 \text{ m/s}$
 (-280 m/s, -80 m/s) 

4. DETERMINE THE UNKNOWN INITIAL OR FINAL VELOCITY FOR EACH OF THE FOLLOWING COLLISIONS. DRAW ITS VECTOR.



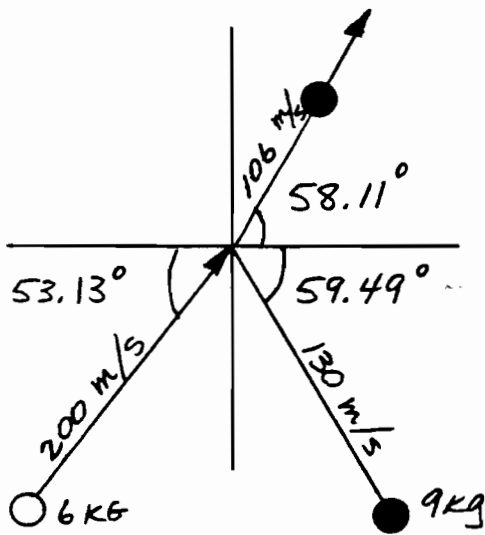
MOMENTUM IN TWO-DIMENSIONS

1. THE 25 KG BLACK BALL IS INITIALLY STATIONARY AT THE ORIGIN. A 10 KG WHITE BALL IS ZOOMING SOUTH DOWN THE Y-AXIS AT 69 m/s. THE WHITE BALL STRIKES THE BLACK WITH A GLANCING BLOW, SENDING THE BLACK INTO THE FOURTH QUADRANT AT 20.8 m/s AT ANGLE 67.38° . FIND:



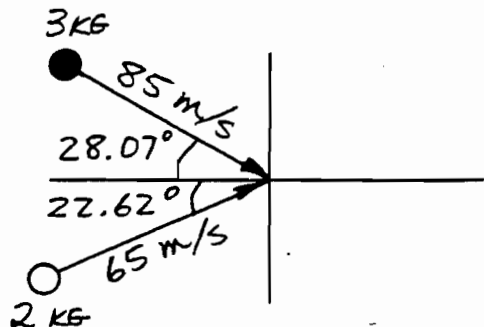
- A) THE FINAL VELOCITY OF THE WHITE BALL. ($V_x = -20$, $V_y = -21$, $V = 29$, $\theta = 46.4^\circ$, 3RD QUADRANT)
- B) THE KINETIC ENERGY TRANSFORMED INTO OTHER FORMS OF ENERGY BY THE COLLISION. (14192 JOULES)

2. THE 6 KG WHITE BALL IS INITIALLY ZOOMING AT 200 m/s IN THE THIRD QUADRANT AT 53.13° . THE 9 KG BLACK BALL IS INITIALLY CRUISING AT 130 m/s AT 59.49° IN THE FOURTH QUADRANT. THE TWO BALLS COLLIDE AT THE ORIGIN, AFTER WHICH THE 9 KG BLACK BALL IS DEFLECTED AT 106 m/s INTO THE FIRST QUADRANT AT 58.11° . FIND:



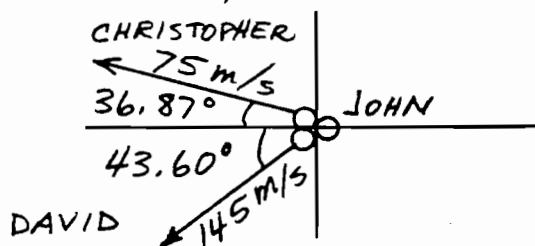
- A) THE FINAL VELOCITY OF THE WHITE BALL. ($V_x = -63$, $V_y = 193$, $V = 203$, $\theta = 71.9^\circ$, 2ND QUADRANT)
- B) THE KINETIC ENERGY TRANSFORMED BY THE COLLISION INTO OTHER FORMS OF ENERGY. (21,861)

3. THE 3 KG BLACK CLAY BALL IS ZOOMING AT 85 m/s AT 28.07° IN THE SECOND QUADRANT. THE 2 KG WHITE CLAY BALL IS CRUISING AT 65 m/s AT 22.62° IN THE THIRD QUADRANT. THE TWO ORBS COLLIDE AT THE ORIGIN AND STICK TOGETHER.



FIND: A) THE FINAL VELOCITY OF THE HUGE GOB OF OREO[®] CLAY. ($V_x = 69$, $V_y = -14$, $V = 70.4$, $\theta = 11.47^\circ$)
 B) FIND THE K.E. LOST IN THE COLLISION. (2670 JOULES)

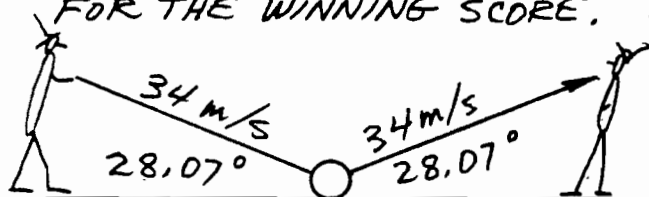
4. JOHN, $m = 50$ KG, DAVID, $m = 70$ KG, AND CHRISTOPHER, $m = 80$ KG, ARE STANDING STATIONARY AT THE ORIGIN ON FRICTIONLESS ICE. DISAGREEING ON WHO WILL WIN THE SUPER BOWL, THEY VIOLENTLY PUSH EACH OTHER APART. CHRISTOPHER CRUISES BACKWARDS INTO THE SECOND QUADRANT AT 75 m/s AT 36.87° . DAVID ZOOMS DOWNWARD INTO THE THIRD QUADRANT AT 145 m/s AT 43.60° .



FIND: A) JOHN'S FINAL VELOCITY. ($V_x = 243$, $V_y = 68$, $V = 252$, $\theta = 15.6$, 1ST QUADRANT)

B) THE TOTAL ENERGY SUPPLIED BY ALL THEIR MUSCLES. (2552,700)

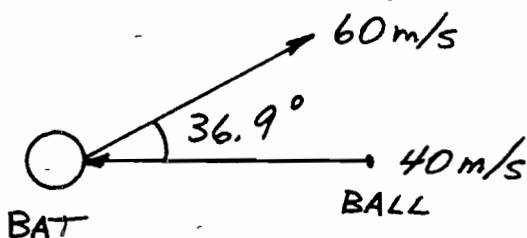
5. FINAL FOUR AT THE SPORTS ARENA! SCOTT MAKES A BOUNCE PASS AT 28.07° AT 34 m/s TO COACH FARRELL, WHO JAMS THE .6 KG BALL THROUGH THE HOOP FOR THE WINNING SCORE. THE BALL WAS IN CONTACT WITH



THE FLOOR FOR .025 SEC. FIND THE FORCE EXERTED ON THE BALL BY THE FLOOR. ($F_x = 0$, $F_y = 768$, $F = 768$, $\theta = 90^\circ$)

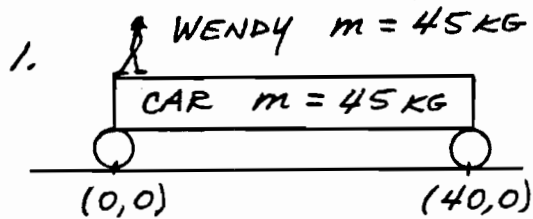
6. NOLAN RYAN PITCHES A .11 KG BASEBALL AT -40 m/s . VINCE SWINGS AND THE BALL TAKES OFF AT 60 m/s AT AN ANGLE OF 36.9° . THE BALL WAS IN CONTACT WITH THE BAT FOR .008 SECONDS.

- A) CALCULATE THE X AND Y COMPONENTS OF THE FORCE ON THE BALL. (1210 N , 495 N)
 B) FIND THE NET FORCE AND THE DIRECTION OF THE FORCE FELT BY THE BALL. (1307 N , 22°)
 C) FIND THE MAGNITUDE AND DIRECTION OF THE FORCE FELT BY THE BAT. (1307 N , 22° , THIRD QUADRANT)



7. A 500 KG PROJECTILE IS SHOT FROM A CANNON AT 50 m/s AT AN ANGLE OF 53.13° . AT THE TOP OF ITS ARC, THE PROJECTILE EXPLODES, BREAKING INTO TWO PIECES WHOSE MASSES ARE 100 KG AND 400 KG. AS A RESULT OF THE EXPLOSION, THE 400 KG PIECE COMES TO REST AT THE ZENITH OF THE TRAJECTORY AND THEN DROPS STRAIGHT TO THE GROUND. FIND: A) THE VELOCITY OF THE 100 KG PIECE IMMEDIATELY AFTER THE EXPLOSION. (150 m/s , 0°)
 B) THE FINAL COORDINATES OF THE 100 KG ($720, 0$)
 C) THE ENERGY PROVIDED BY THE EXPLOSION. (900000 JOULES)
8. ANOTHER 500 KGS IS SHOT AT 50 m/s AT 53.13° . AT THE APEX, AN EXPLOSION THROWS A 400 KG PIECE STRAIGHT DOWN AT -20 m/s . AS IN QUESTION SEVEN, FIND: A) VELOCITY OF 100 KGS. (170 m/s AT 28.07°)
 B) FINAL COORDINATES OF 100 KGS. ($2662, 0$)
 C) THE ENERGY OF THE EXPLOSION. (1300000 JOULES)

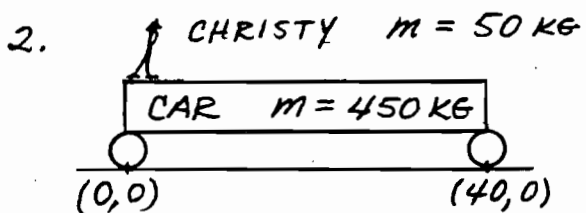
THE MOTION OF OBJECTS IN FRICTION-FREE ENVIRONMENTS



a) FIND THE PRESENT LOCATION OF THE CENTER OF MASS OF THE ENTIRE SYSTEM.

b) WENDY NOW WALKS TO THE CENTER OF THE CAR AND STOPS. FIND THE COORDINATES OF BOTH WHEELS.

c) WENDY NOW WALKS TO THE RIGHT END OF THE CAR. FIND THE COORDINATES OF BOTH WHEELS.

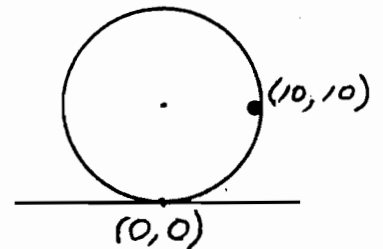


a) FIND THE PRESENT LOCATION OF THE CENTER OF MASS OF THE ENTIRE SYSTEM.

b) CHRISTY NOW WALKS TO THE CENTER OF THE CAR AND STOPS. FIND THE COORDINATES OF BOTH WHEELS.

c) CHRISTY NOW WALKS TO THE RIGHT END OF THE CAR AND STOPS. FIND THE COORDINATES OF BOTH WHEELS.

3. A HOLLOW SPHERE OF MASS $m = 8 \text{ kg}$ AND RADIUS $R = 10 \text{ m}$ RESTS ON FRICTIONLESS ICE AT $(0,0)$. A TINY 8 kg MARBLE IS INITIALLY AT REST AT $(10,10)$ ON THE INNER EDGE OF THE SHELL.

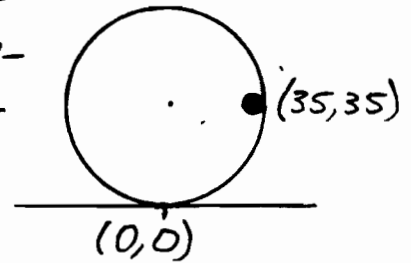


a) FIND THE PRESENT LOCATION OF THE CENTER OF MASS OF THE ENTIRE SYSTEM.

b) WE NOW RELEASE THE MARBLE. DUE TO FRICTION ON THE INNER SURFACE OF THE SHELL, THE MARBLE COMES TO REST AT THE BOTTOM OF THE SHELL. FIND THE FINAL LOCATION OF THE BASE OF THE SHELL.

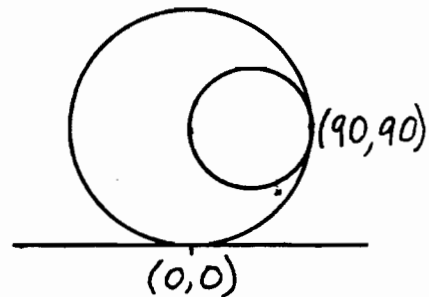
c) FIND THE FINAL COORDINATES OF THE CENTER OF MASS.

4. A HOLLOW SHELL OF MASS $m = 24 \text{ kg}$ AND RADIUS $R = 35 \text{ m}$ RESTS ON FRICTIONLESS ICE AT $(0,0)$. A TINY 4 kg MARBLE IS INITIALLY AT REST AT $(35, 35)$. ON THE INNER SURFACE OF THE SHELL.



- FIND THE PRESENT LOCATION OF THE CENTER OF MASS.
- WE RELEASE THE MARBLE, WHICH EVENTUALLY COMES TO REST AT THE BOTTOM OF THE SHELL. FIND THE FINAL LOCATION OF THE MARBLE.
- FIND THE FINAL LOCATION OF THE CENTER OF MASS.

5. A HOLLOW SHELL OF MASS $m_1 = 24 \text{ kg}$ AND RADIUS $R_1 = 90 \text{ m}$ RESTS AT $(0,0)$. INSIDE THE SHELL RESTS A SOLID BALL OF MASS $m_2 = 6 \text{ kg}$ AND RADIUS $R_2 = 45 \text{ m}$ WHICH IS TANGENT TO THE SHELL AT $(90, 90)$.



- FIND THE PRESENT LOCATION OF THE CENTER OF MASS.
 - WE RELEASE THE SOLID BALL, WHICH EVENTUALLY COMES TO REST AT THE BOTTOM OF THE SHELL. FIND THE FINAL LOCATION OF THE BASE OF THE SHELL.
 - FIND THE FINAL LOCATION OF THE CENTER OF MASS.
6. JASON, $m = 70 \text{ kg}$, AND CATIE SIT AT OPPOSITE ENDS OF A MASSLESS 24 m LONG CANOE, WHICH IS INITIALLY AT REST. WHEN THEY EXCHANGE PLACES, THE CANOE MOVES 4 m THROUGH THE WATER BEFORE AGAIN COMING TO REST. FIND CATIE'S MASS.

ANSWERS: $(10, 0)$, $(-10, 0)$, $(30, 0)$, $(-20, 0)$, $(20, 0)$; $(18, 0)$, $(-2, 0)$, $(38, 0)$, $(-4, 0)$, $(36, 0)$; $(5, 10)$, $(5, 0)$, $(5, 5)$; $(5, 35)$, $(5, 0)$, $(5, 30)$; $(9, 90)$, $(9, 0)$, $(9, 81)$; 50 kg ; 98 kg IS NOT THE ANSWER.