KINEMATICS

1. PLAY BALL! A BASEBALL FOLLOWS A PARABOLIC TRAJECTORY AS IT ZOOMS THROUGH THE SKY. AT ONE POINT, ITS POSITION IS (48, 36). .16 SECONDS LATER, ITS POSITION IS (60, 25).

A) FIND THE DISTANCE FROM THE ORIGIN FOR BOTH POINTS.

B) FOR THE INTERVAL BETWEEN THE TWO POINTS, FIND:

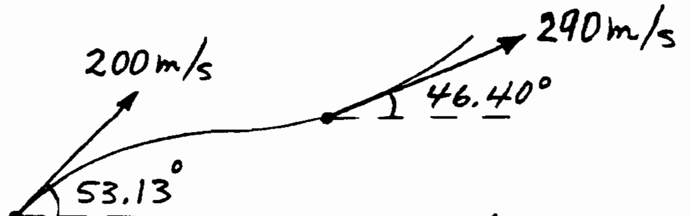
i) CHANGE IN POSITION, $\Delta\vec{r}$.
ii) AVERAGE VELOCITY, $\overline{\vec{v}}$.
iii) DISTANCE TRAVELED, S.
iv) AVERAGE SPEED, $\overline{v}$.

ANSWERS:
60 m, 65 m,
(12, −11), (75, −68.75)
16.28, 101.74

2. FORE! FROM THE ORIGIN ON THE TEE, MR. H HITS THE GOLF BALL TO LOCATION (−50, 120). AT THIS POINT, THE WAYWARD GOLFER HITS THE BALL SO THAT ITS DISPLACEMENT IS (30, 16) FROM THAT POINT. FROM THIS SECOND LIE, MR. H. SMACKS THE BALL SO THAT IT IS DISPLACED (90, −56) FROM THAT LOCATION. THESE THREE SHOTS TOOK A TOTAL TIME OF 20 SEC. FIND THE:

A) TOTAL DISPLACEMENT FROM THE TEE. ((70, 80))
B) AVERAGE VELOCITY FOR THE ENTIRE TRIP. ((3.5, 4))
C) TOTAL DISTANCE TRAVELED. (270)
D) AVERAGE SPEED FOR THE ENTIRE TRIP. (13.5)
E) FROM THE TEE, THE HOLE'S LOCATION IS (22, 135). FROM THE PRESENT LOCATION OF THE BALL, FIND THE DISPLACEMENT SO THAT THIS FOURTH SHOT PUTS THE BALL IN THE HOLE. ((−48, 55))
F) FIND THE LENGTH AND DIRECTION OF THE DESIRED, WONDERFUL FOURTH SHOT. (73 AT 48.89°, SECOND QUADRANT)

3. WARP FIVE, SCOTTY! THE STARSHIP ENTERPRISE ACCELERATES FOR 2.5 SECONDS ALONG THE FOLLOWING CURVED PATH. FIND:



A) ΔV_x B) ΔV_y
C) $\overline{\vec{a}}$
D) $\overline{a}$, AVERAGE PICK-UP

(80, 50, (32, 20), 37.74)

KINEMATICS FOR CONSTANT ACCELERATION

1. ALAN, BOUNCING ON A POGO STICK, LEAVES THE GROUND WITH A VELOCITY OF 30 m/s.

a) DETERMINE THE TOTAL TIME THAT HE IS AIRBORNE. (6)

b) FIND HIS MAXIMUM ELEVATION. (45 m)

c) TIME TO REACH THE ZENITH. (3 SEC)

d) WITH WHAT VELOCITY DOES HE STRIKE THE GROUND? (−30)

e) AFTER HOW MANY SECONDS IS HIS <u>SPEED</u> 5 m/s? (2.5 + 3.5)

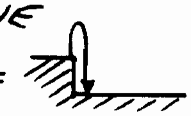
2. KEVIN, ATOP A 30 m HIGH TOWER, THROWS A WATERMELON DOWN WITH AN INITIAL VELOCITY OF −20 m/s.

a) FIND THE TOTAL TIME AIRBORNE. (1.16 SEC)

b) WITH WHAT VELOCITY DOES THE GREEN ELLIPSOID KISS THE CONCRETE? (−31.6 m/s)

c) FIND ITS ELEVATION WHEN ITS VELOCITY IS −25 m/s (18.75 m)

3. ANNA STANDS ATOP A BUILDING WHICH IS 50 m HIGH. SHE FLINGS AN ORANGE STRAIGHT UPWARDS. WHEN THE IRISH FRUIT IS 8 m ABOVE THE TOP OF THE BUILDING, ITS VELOCITY IS 40 m/s. THE PATH:



a) FIND THE INITIAL VELOCITY OF THE CITRUS. (42 m/s)

b) THE TOTAL TIME AIRBORNE. (9.46 SEC)

c) WHAT IS ITS VELOCITY FIVE SECONDS AFTER ANNA FIRES IT UPWARD? (−8)

d) DETERMINE ITS ELEVATION ABOVE THE GROUND WHEN ITS SPEED IS 25 m/s. (107 m)

e) AT WHAT TIME IS ITS ELEVATION 105 m ABOVE THE GROUND? (6.78, 1.62 SEC)

f) TIME TO REACH ITS ZENITH. (4.2 SEC)

g) TIME FROM THE APEX TO THE GROUND. (5.26 SEC)

h) AVERAGE VELOCITY AND AVERAGE SPEED FOR THE ENTIRE TRIP. (−5.3 m/s, 23.9 m/s)

KINEMATICS FOR NON-CONSTANT ACCELERATION

1. THE POSITION OF KENNY'S PORSCHE AS HE ZOOMS DOWN THE X-AXIS IS GIVEN BY: $x = 5t^3 + 4t^2 + 3t + 6$.

A) FIND FORMULAS FOR HIS VELOCITY AND FOR HIS ACCELERATION AS FUNCTIONS OF TIME.

B) FIND HIS INITIAL POSITION, VELOCITY AND ACCELERATION.

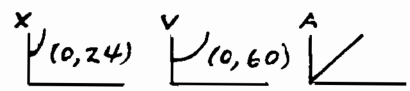
C) FIND HIS AVERAGE VELOCITY FOR THE FIRST THREE SECONDS.

($v = 15t^2 + 8t + 3$, $A = 30t + 8$, 6m, 3m/s, 8m/s^2, 60 m/s)

2. THE ACCELERATION OF OLIVER'S BMW AS HE ZOOMS DOWN THE X-AXIS IS GIVEN BY: $a = 42t$. AT $t = 2$, HIS VELOCITY IS $V = 144$ AND HIS POSITION IS $X = 200$.

A) FIND FORMULAS FOR HIS VELOCITY AND FOR HIS POSITION AS FUNCTIONS OF TIME.

B) WITH TIME ON THE HORIZONTAL AXIS, SKETCH GRAPHS OF X, V, AND A VERSUS t, FOR $t \geq 0$.

($V = 21t^2 + 60$, $X = 7t^3 + 60t + 24$, 

)

3. THE BELL RINGS AND MR. H DASHES OUT THE DOOR OF ROOM 25. HOWEVER, HE IS ATTACHED TO HIS DESK BY A BUNGEE CORD. HIS POSITION ALONG THE X-AXIS IS GIVEN BY: $X = 60t^2 - 5t^3$.

A) FIND FORMULAS FOR HIS VELOCITY AND FOR HIS ACCELERATION AS FUNCTIONS OF TIME.

B) AT WHAT TIME IS HIS POSITION ZERO?

C) AT WHAT TIME IS HIS VELOCITY ZERO?

D) AT WHAT TIME IS HIS ACCELERATION ZERO?

E) DURING WHAT TIME INTERVAL IS HIS POSITION POSITIVE; IS HIS VELOCITY POSITIVE; IS HIS ACCELERATION POSITIVE?

F) SKETCH A GRAPH OF HIS MOTION ON THE X-Y AXIS.

G) SKETCH X-t, V-t AND A-t CURVES.

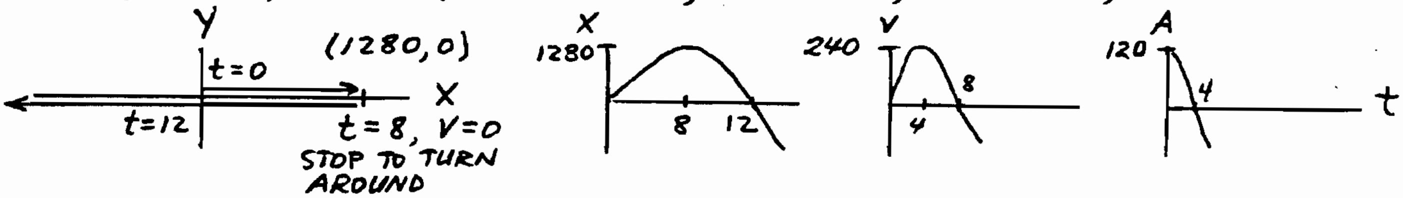
H) FIND HIS LOCATION AT $t = 1$ AND AT $t = 10$.

I) FIND HIS AVERAGE VELOCITY FROM $t = 1$ TO $t = 10$.

J) FIND HIS AVERAGE SPEED FROM $t = 1$ TO $t = 10$.

K) FIND HIS AVERAGE VELOCITY AND AVERAGE SPEED FROM $t = 1$ TO $t = 13$.

(ANSWERS: $V = 120t - 15t^2$, $A = 120 - 30t$; $t=0, t=12$; $t=0, t=8$; $t=4$; $0<t<12$, $0<t<8$, $0<t<4$;



55, 1000; 105; 167.22; −75, 279.17)

4. THE SPACE SHUTTLE ACCELERATES NON-UNIFORMLY WITH: $A = 25(1 - e^{-t})$.

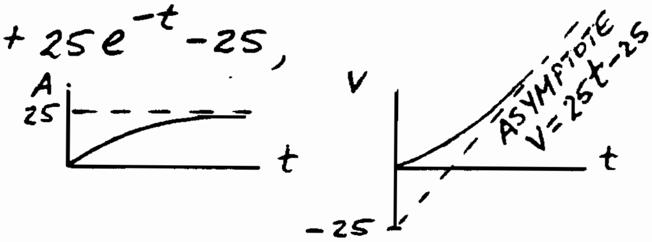
A) FIND ITS ACCELERATION AT $t = 0$ AND AT $t = \infty$.

B) THE SHUTTLE'S INITIAL VELOCITY IS ZERO. FIND A FORMULA FOR ITS VELOCITY AS A FUNCTION OF TIME.

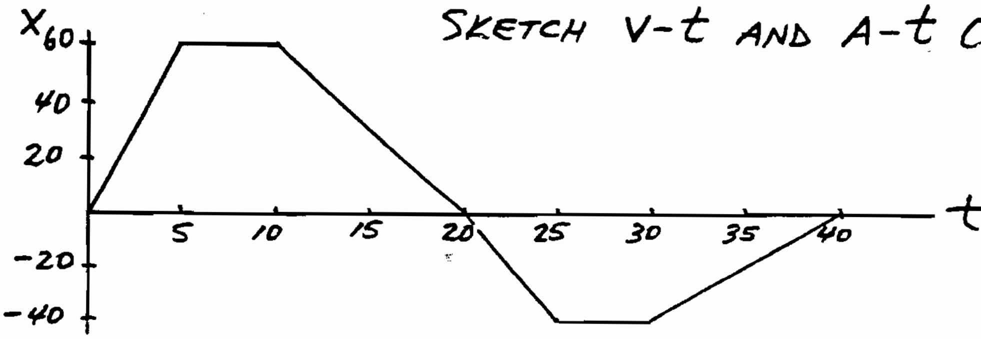
C) THE SHUTTLE'S INITIAL POSITION IS ZERO. FIND A FORMULA FOR ITS POSITION AS A FUNCTION OF TIME.

D) SKETCH A−t AND V−t CURVES.

(ANSWERS: 0, 25; $V = 25t + 25e^{-t} - 25$, $Y = 12.5t^2 - 25e^{-t} - 25t + 25$,

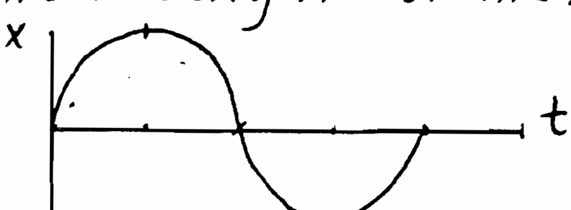


5. A PARTICLE MOVES BACK AND FORTH ALONG THE X−AXIS ACCORDING TO THE POSITION GRAPH SHOWN BELOW. SKETCH V−t AND A−t CURVES.

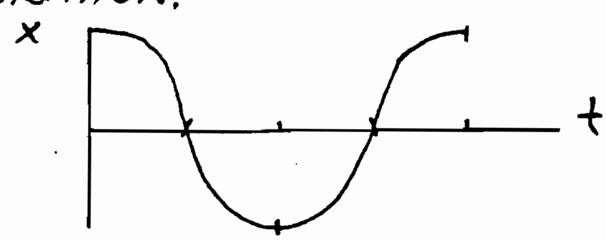


6. FOR EACH SEGMENT OF EACH CURVE, FIND THE PARITY OF THE VELOCITY AND OF THE ACCELERATION.

A)

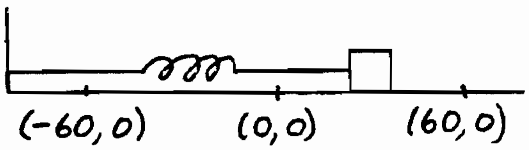


B)



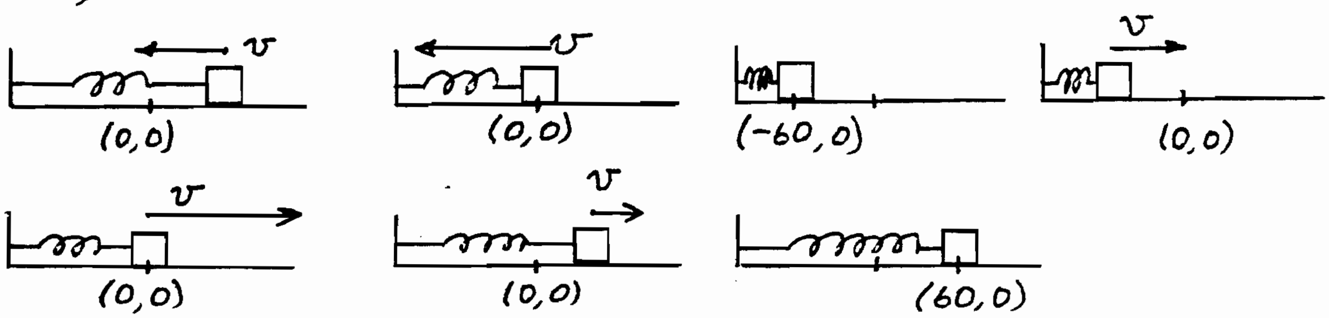
(ANSWERS: V: +, −, −, +, −, −, +, +. A: −, −, +, +, −, +, +, −)

7. A PARTICLE ATTACHED TO A SPRING IS CONFINED TO MOVE BACK AND FORTH ON THE HORIZONTAL AXIS BEWEEN $X = 60$ AND $X = -60$. NO FRICTION.



THE ORIGIN IS THE EQUILIBRIUM POSITION.

A) INTUITIONS. FOR EACH OF THE FOLLOWING, DETERMINE THE PARITY OF X, V AND A. THAT IS, TELL IF THEY ARE (+), (−) OR ZERO.



B) THE POSITION OF THE PARTICLE IS GIVEN BY:

$X = 60 \cos(.523597756\, t)$ WHERE $\omega = .52\ldots$ RADIANS/SEC.

FIND A FORMULA FOR THE PARTICLE'S VELOCITY AND ACCELERATION.

c) AT $t = 0, 3, 6, 9$ AND 12 SECONDS, CALCULATE THE PARTICLE'S POSITION, VELOCITY AND ACCELERATION. PLEASE SET YOUR CALCULATOR ON RADIANS.

d) CALCULATE THE PARTICLE'S AVERAGE VELOCITY, $\bar{V}$, FOR THE FOLLOWING TIME INTERVALS. FROM:

i) $t=0$ TO $t = 12$ SEC
ii) $t=0$ TO $t = 3$ SEC
iii) $t=0$ TO $t = 6$ SEC
iv) $t=6$ TO 9 SEC
v) $t=6$ TO 12 SEC
vi) $t=3$ TO 12 SEC

e) CALCULATE THE PARTICLE'S AVERAGE SPEED, $|\bar{V}|$, FOR THOSE SAME TIME INTERVALS.

f) WHEN $X=30$, CALCULATE t, v AND a.

ANSWERS: +,−,−; 0,−,0; −,0,+; −,+,+; 0,+,0; +,+,−; +,0,−;

$v = -31.415862 \sin .523597756t$ $\quad a = -16.449 \cos .5235977t$

$t=0$: 60 m, 0 m/s, −16.449 m/s²; 0, −31, 0; −60, 0, 16; 0, 31, 0; 60, 0, −16;

$\bar{v}$ = 0 m/s, −20, −20, 20, 20, 6.67 m/s; $|\bar{v}|$ = 20 m/s, 20, 20, 20, 20, 20

$t = 2$ sec; $v = -27.2069$ m/s, $a = -8.2245$ m/s²

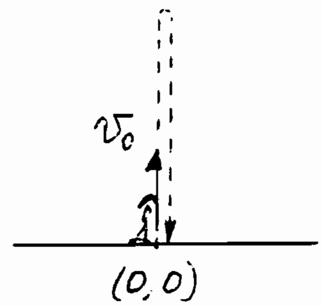
UNITS

1. FIND THE S.I. UNITS FOR THE GRECIAN LETTERS.

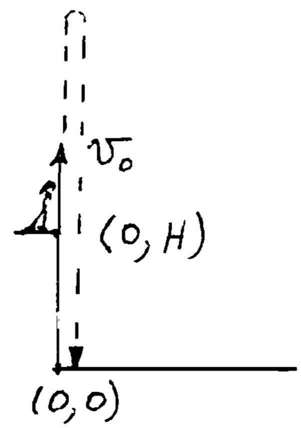
A) $V = \alpha t + \beta / t^3 + \gamma \alpha t^4 + \delta \beta x t + \epsilon \sqrt{a x}$

B) $a = \alpha (1 - e^{-\beta t^2})$

KINEMATICS: VEGETABLE SOUP



1. FIND A FORMULA FOR THE TOTAL TIME, t, THAT THE TURNIP IS AIRBORNE. FROM GROUND LEVEL, DIANA HAS THROWN IT VERTICALLY UPWARD AT VELOCITY v_0. ONLY v_0 AND g ARE ALLOWED IN YOUR ANSWER.



2. FIND A FORMULA FOR THE TOTAL TIME, t, THAT THE SWEET POTATO IS AIRBORNE. FROM ATOP A SILO OF HEIGHT, H, ANNA THROWS IT VERTICALLY UPWARD AT VELOCITY v_0. THE SPUD FALLS TO GROUND LEVEL. ONLY H, v_0 AND g ARE ALLOWED IN YOUR ANSWER.

ANSWERS: ($[m/s^2]$, $[m s^2]$, $[1/sec^3]$, $[1/m s^4]$, NO UNITS; $[m/s^2]$, $[1/sec^2]$)

ANSWERS: 1. $t = 2 v_0 / g$

2. $t = \dfrac{v_0 + \sqrt{v_0^2 + 2 g H}}{g}$

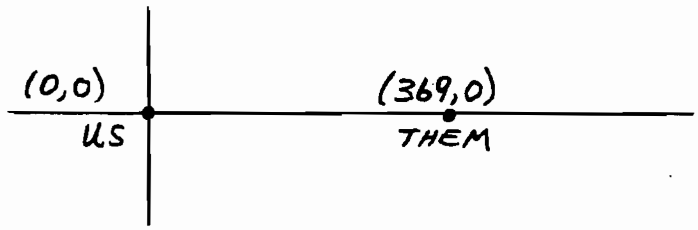
SIMULTANEOUS MOTION

1. EARTHQUAKE!

A) P-WAVES, TRAVELING AT 15 km/s HIT OUR HOME. TWENTY-SIX SECONDS LATER, THE S-WAVES, TRAVELING AT 5 km/s, STRIKE. FIND THE DISTANCE TO THE EPICENTER. (195 km)

B) ANOTHER ABODE, 369 km FROM OUR HOUSE, DETERMINES THAT THE EPICENTER WAS 318 km AWAY FROM THEM. FIND THE COORDINATES OF THE EPICENTER ON THE MAP BELOW:

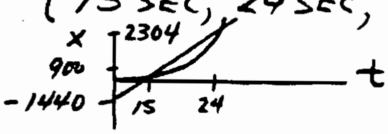
ANSWER:
(99, 168) OR
(99, −168)



2. GREEN LIGHT! THE PORSCHE, FROM REST AT THE ORIGIN, ACCELERATES AT $8\ m/s^2$. AT THE SAME INSTANT, A BMW IS 1440 m BEHIND THE PORSCHE AND IS MOVING AT CONSTANT VELOCITY OF 156 m/s.

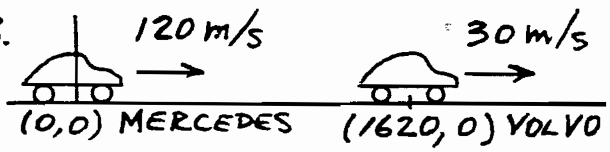
A) FIND WHEN AND WHERE THEY PASS EACH OTHER.
B) FIND THEIR VELOCITIES WHEN THEY ARE SIDE BY SIDE.
C) SKETCH AN X-t GRAPH SHOWING BOTH OF THEIR DISPLACEMENT CURVES.

(15 sec, 24 sec, 900 m, 2304 m, 120 m/s, 156 m/s, 192 m/s, 156 m/s,



)

3.



RIGHT NOW, THE MERCEDES BEGINS TO BRAKE WHILE THE VOLVO CONTINUES AT CONSTANT VELOCITY. FIND:

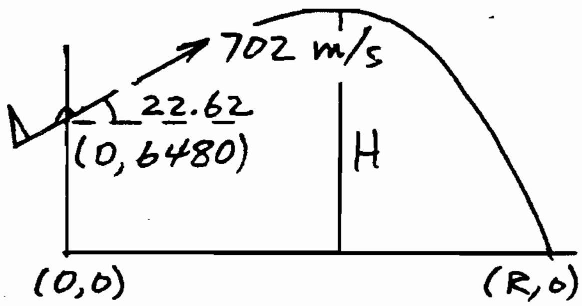
A) THE DECELERATION OF THE MERCEDES SO THAT THEY KISS.
B) THE TIME AND LOCATION OF THEIR KISS. (−2.5, 36, 2700)

4. A TRAIN, V = 40 km/HR, IS MOVING HEAD-ON TOWARD ANOTHER WHOSE V = −50 km/HR. WHEN THEY ARE 225 km APART, A BIRD BEGINS FLYING BACK AND FORTH BETWEEN THEM AT 76 km/HR. HOW FAR DOES THE BIRD FLY TOTALLY BEFORE THE TRAINS COLLIDE? (190 km)

PROJECTILE MOTION : TWO-DIMENSIONAL MOTION WITH CONSTANT ACCELERATION

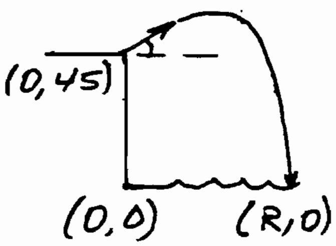
1. ROSE BOWL! KICK-OFF! STACEY BOOTS THE FOOTBALL WHICH LANDS 84 m DOWNFIELD AFTER BEING AIRBORNE FOR A TOTAL OF FOUR SECONDS.
FIND: a) v_{ox} b) v_{oy} c) v_o TOTAL d) θ_o
e) THE MAXIMUM ELEVATION OF THE PIGSKIN.
(21 m/s, 20 m/s, 29 m/s, 43.6°, 20 m)

2. KEN IS FLYING HIS T.P.H.S. F-16 FALCON UPWARD AT ANGLE 22.62° AT SPEED 702 m/s. WHEN HIS ALTITUDE IS 6480 m, KEN DROPS A SAMSONITE® BRIEFCASE FROM THE JET. FIND:



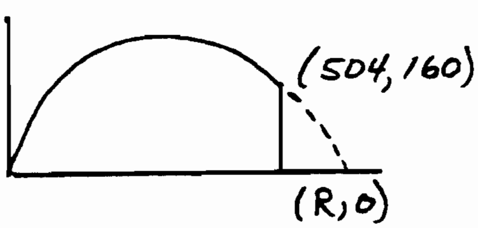
a) TOTAL TIME AIRBORNE (72 SEC)
b) THE RANGE OF THE VALISE. (46656)
c) ITS MAXIMUM ELEVATION (10125)

3. CHRISTIAN, DIVING FROM THE CLIFFS OF ACAPULCO AT AN ANGLE OF 28.07°, ZOOMS THROUGH THE AIR FOR NINE SECONDS BEFORE SLICING INTO THE OCEAN, 45 m BELOW. FIND: a) v_{oy} b) v_o TOTAL
c) v_{ox} d) RANGE
e) MAXIMUM ELEVATION.



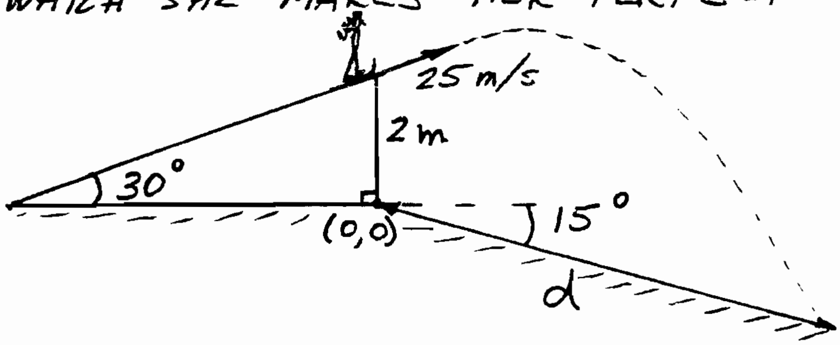
(40 m/s, 85 m/s, 75 m/s, 675 m, 125 m)

4. WORLD SERIES! LIZ CRUSHES A PITCH INTO THE STANDS AT LOCATION (504, 160) FOR A HOME RUN. THE BALL WAS AIRBORNE FOR EIGHT SECONDS. FIND:

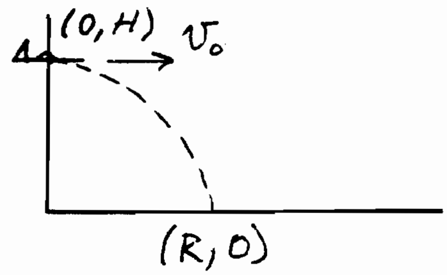


a) v_{ox} b) v_{oy}
c) THE RANGE OF THE BALL IF IT HAD NOT HIT THE STANDS.
(63 m/s 60 m/s, 756 m)

5. VANESSA SKIS OFF A JUMP WHICH SLOPES UPWARD AT 30°. FIND THE DISTANCE "d" AT WHICH SHE MAKES HER PERFECT LANDING. (84.42 m)

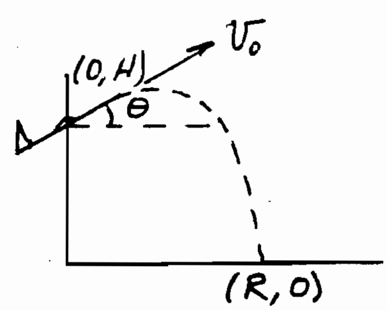


6. JAYA IS FLYING HER T.P.H.S. FALCON HORIZONALLY AT VELOCITY v_0 AT ALTITUDE H WHEN SHE RELEASES A MAUI ONION. FIND A FORMULA FOR THE RANGE R OF THE FLYING BULB. ONLY v_0, H AND g ARE ALLOWED IN OUR ANSWER.



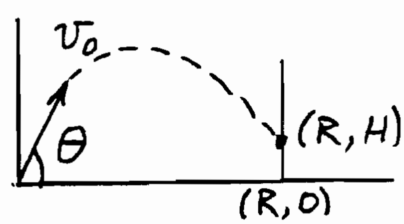
(ANSWER: $R = v_0\sqrt{2H/g}$)

7. JULIE IS FLYING HER F-16 FALCON AT ALTITUDE H AT VELOCITY v_0 AT UPWARD ANGLE θ. AT THIS INSTANT, SHE RELEASES A TOMATO. FIND A FORMULA FOR THE RANGE OF THE FRUIT. ONLY H, v_0, θ AND g ARE ALLOWED IN OUR ANSWER.



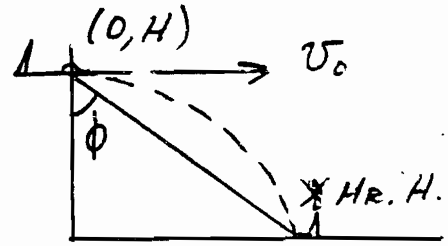
$$\left(R = \frac{v_0^2 \sin\theta\cos\theta + v_0\cos\theta\sqrt{v_0^2\sin^2\theta + 2gH}}{g} \right)$$

8. MIKE HITS A BASEBALL WITH INITIAL VELOCITY v_0 AT ANGLE θ. THE BALL LANDS IN THE STANDS AT DISTANCE R FROM HOME PLATE. FIND A FORMULA FOR THE FINAL ELEVATION OF THE BALL. ONLY v_0, θ, R AND g ARE ALLOWED IN OUR ANSWER.



$$\left(H = R\tan\theta - \frac{gR^2}{2v_0^2\cos^2\theta} \right)$$

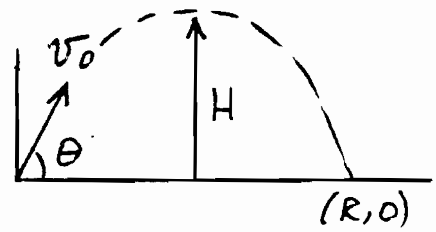
9. ROB IS FLYING HIS F-16 FALCON HORIZONTALLY AT ALTITUDE H AT VELOCITY v_0. FIND A FORMULA FOR THE LINE-OF-SIGHT ANGLE ϕ SO THAT A KIWI RELEASED AT THIS INSTANT WILL HIT ITS TARGET. ONLY H, v_0 AND g ARE ALLOWED IN OUR ANSWER. $\left(\phi = \tan^{-1}\left[\left(\frac{2v_0^2}{gH}\right)^{1/2}\right]\right)$



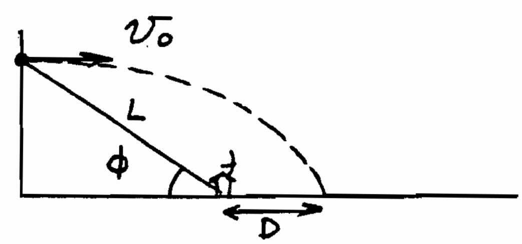
10. CHRISTOPHER HEAVES A SHOT PUT FROM THE ORIGIN AT VELOCITY v_0 AT ANGLE θ.
IN TERMS OF v_0, θ AND g, FIND FORMULAS FOR:

A) THE MAXIMUM ELEVATION H.
B) THE RANGE R.
C) EQUATE THE FORMULAS FOR H AND R AND FIND THE ANGLE OF PROJECTION θ AT WHICH THE MAXIMUM ELEVATION ACHIEVED BY A PROJECTILE WOULD EQUAL ITS RANGE.

$$\left(H = \frac{v_0^2 \sin^2\theta}{2g},\ R = \frac{2v_0^2 \sin\theta\cos\theta}{g},\ 76^\circ\right)$$



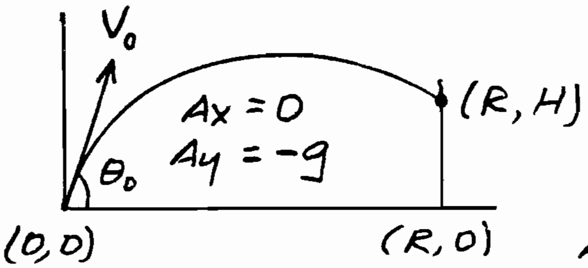
11. A RADAR STATION DETECTS A PROJECTILE AT THE APEX OF ITS TRAJECTORY. THE INSTRUMENTS DETERMINE THE VELOCITY, v_0, OF THE PROJECTILE, THE STRAIGHT LINE DISTANCE, L, TO IT AND THE ANGLE, ϕ, OF OUR LINE OF SIGHT. FIND A FORMULA FOR THE DISPLACEMENT, D, FROM THE RADAR STATION TO THE POINT OF IMPACT. ONLY v_0, L, ϕ AND g ARE ALLOWED IN OUR ANSWER.



$$\left(D = v_0\sqrt{\frac{2L\sin\phi}{g}} - L\cos\phi\right)$$

NOTE: IF THE RADAR'S COMPUTER PUTS IN THE NUMBERS AND CALCULATES D TO BE (+), THE MISSLE PASSES OVERHEAD; D (−), IT HITS IN FRONT OF US. IF $D=0$, ABANDON SHIP!

12. WORLD SERIES! EVAN BELTS THE BALL AT VELOCITY V_0 AT ANGLE θ_0. AT RANGE R FROM HOME PLATE, THE BALL STRIKES THE WALL FOR A GAME-WINNING HOME RUN.



A) IN TERMS OF V_0, θ_0, R AND g, FIND A FORMULA FOR THE HEIGHT H AT WHICH THE BALL HITS THE WALL.

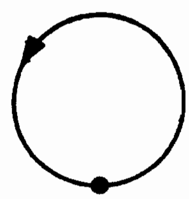
ANSWER: $H = R \tan\theta_0 - \dfrac{gR^2}{2V_0^2\cos^2\theta_0}$

B) IN TERMS OF V_0, R AND g, FIND A FORMULA FOR θ_0 SO THAT H IS MAXIMUM. ANSWER: $\theta_0 = \tan^{-1}\left(V_0^2/gR\right)$.

TWO-DIMENSIONAL KINEMATICS WITH $\vec{a} \neq$ CONSTANT

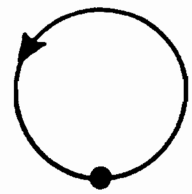
1. DEIRDRE TWIRLS A MANDARIN ORANGE ON THE END OF A STRING WHOSE LENGTH IS 3 m. CRUISING AROUND THE CIRCULAR PATH AT CONSTANT SPEED, THE CHINESE CITRUS TAKES EIGHT SECONDS TO MAKE ONE REVOLUTION. FIND: a) THE FREQUENCY (.125 Hz) b) THE ANGULAR VELOCITY ($\pi/4 = .785\ \text{sec}^{-1}$) c) THE SPEED (2.356 m/s) d) THE RADIAL ACCELERATION (1.85 m/s²)

2. ATLANTA 1996! JOHN IS DOING THE HAMMER THROW, WHICH CONSISTS OF A STEEL ORB TIED TO THE END OF A CHAIN .6 m LONG. JOHN GRABS THE FREE END OF THE CHAIN AND WHIRLS AROUND, ACCELERATING THE MASS IN A CIRCULAR PATH FROM 0 TO 30 m/s IN 1.2 SECONDS. FIND THE: a) TANGENTIAL ACCELERATION (25 m/s²)
b) ANGULAR ACCELERATION ($41.66\ \text{sec}^{-2}$)
WE FREEZE-FRAME HIS EVENT .24 SECONDS AFTER HE FIRST STARTED TO WHIRL AROUND. FIND THE:
c) LINEAR SPEED, v (6 m/s)
d) ANGULAR VELOCITY, ω ($10\ \text{sec}^{-1}$)
e) FREQUENCY, f (1.59 Hz)
f) RADIAL ACCELERATION, a_r (60 m/s²)
g) TOTAL ACCELERATION, a_{TOTAL} (65 m/s² AT 67.38°)
h) SKETCH a_r, a_T, a_{TOTAL} AND θ ON THE DIAGRAM.



3. TORREY PINES HIGH SCHOOL, DEL MAR, CALIFORNIA IS LOCATED AT 33°N LATITUDE. THE RADIUS OF THE EARTH IS 6.4×10^6 m. AS THE WORLD TURNS, FIND THE:
A) RADIUS OF OUR ROTATION B) PERIOD C) FREQUENCY
D) ANGULAR SPEED E) LINEAR SPEED
F) RADIAL ACCELERATION.
(5.3675×10^6 m, 86400 sec, 1.16×10^{-5} Hz, $7.27 \times 10^{-5}\ \text{sec}^{-1}$, 390 m/s, .0284 m/s²)

4. DAVID IS RIDING THE WILDEBEEST ON THE EDGE OF THE MERRY-GO-ROUND, WHOSE RADIUS IS 14 m. THE CAROUSEL SLOWS FROM 55 m/s TO 19 m/s IN .4 SEC.
A) FIND THE TANGENTIAL ACCELERATION. ($-90\ m/s^2$)
WE FREEZE-FRAME THE CAROUSEL .3 SECONDS AFTER IT FIRST BEGAN TO DECELERATE. FIND THE:
B) SPEED OF THE GNU. (28 m/s)
c) RADIAL ACCELERATION ($56\ m/s^2$)
d) TOTAL ACCELERATION ($106\ m/s^2$ AT $31.89°$)
e) SKETCH a_r, a_T, a_{TOTAL} AND θ ON THE DIAGRAM.

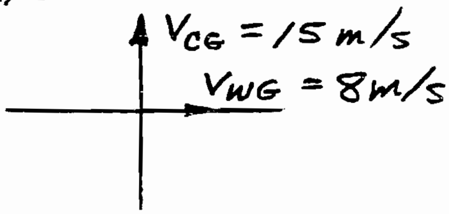


RELATIVE VELOCITIES

1. ALEX, STANDING STILL ON THE GROUND, WATCHES A RAILROAD CAR ROLL TO THE RIGHT AT 20 m/s. ANDY WALKS ALONG THE TOP OF THE CAR TO THE LEFT AT −8 m/s RELATIVE TO THE CAR. ANDY IS HOLDING A TRAY UPON WHICH A MACAW IS HOPPING AT 5 m/s TO THE RIGHT RELATIVE TO ANDY. FIND THE VELOCITY OF THE:
a) BIRD AS SEEN BY ALEX (17 m/s)
b) ANDY AS SEEN BY ALEX (12 m/s)
c) ALEX AS SEEN BY ANDY (−12 m/s)

2. ALEX STANDS ON THE GROUND. ANDY WALKS ALONG THE CAR AND THE MACAW HOPS ALONG THE TRAY. ALEX SEES THE BIRD CRUISING TO THE RIGHT AT 35 m/s. RELATIVE TO THE CAR, ANDY MARCHES TO THE LEFT AT −12 m/s. THE MACAW SEES ANDY MARCHING TO THE LEFT AT −15 m/s. FIND THE VELOCITY OF THE:
a) BIRD AS SEEN BY ANDY. (15 m/s)
b) CAR AS SEEN BY ALEX. (32 m/s)
c) BIRD AS SEEN BY THE CAR. (3 m/s)
d) CAR AS SEEN BY THE BIRD. (−3 m/s)
e) ANDY AS SEEN BY ALEX. (20 m/s)

3. JAMIE RIDES HIS BIKE AT 15 m/s DUE NORTH ALONG THE CALIFORNIA COASTLINE. AN ONSHORE BREEZE OF 8m/s BLOWS DUE EAST.



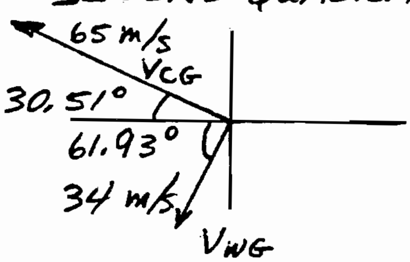
C = CYCLIST
W = WIND
G = GROUND

V_{CG} = VELOCITY OF CYCLIST RELATIVE TO THE GROUND.
V_{WG} = VELOCITY OF WIND RELATIVE TO THE GROUND.

a) WITHOUT ADO, WHAT ARE THE X AND Y PARTS OF V_{WG}.
b) SIMILARLY, WHAT ARE THE X AND Y PARTS OF THE GROUND RELATIVE TO THE CYCLIST, V_{GC}.
c) USING THE EQUATION: $\vec{V}_{WC} = \vec{V}_{WG} + \vec{V}_{GC}$, FIND THE X AND Y PARTS OF THE VELOCITY OF THE WIND RELATIVE TO THE CYCLIST.
d) USE PYTHAGORAS' THEOREM TO FIND THE RESULTING SPEED AND DIRECTION OF THE WIND AS SEEN BY THE CYCLIST.

($V_x = 8$, $V_y = 0$; $V_x = 0$, $V_y = -15$; $V_x = 8$, $V_y = -15$; $V = 17$ AT $-61.93°$ IN FOURTH QUADRANT)

4. TOUR DE FRANCE! GREG LE MONDE CYCLES INTO THE FRENCH ALPS AT 65 m/s AT 30.51° NORTHWEST INTO THE SECOND QUADRANT. A NORTHEAST WIND BLOWS AT 61.93° INTO THE THIRD QUADRANT WITH SPEED OF 34 m/s.



a) USING THE EQUATION $\vec{V}_{WC} = \vec{V}_{WG} + \vec{V}_{GC}$, FIND THE X AND Y PARTS OF THE VELOCITY OF THE WIND AS SEEN BY THE CYCLIST. ($V_x = 40$ m/s, $V_y = -63$ m/s)
b) EMPLOY THE PYTHAGOREAN THEOREM TO FIND THE SPEED AND DIRECTION OF THE WIND RELATIVE TO THE CYCLIST.
($V = 74.63$ m/s AT $-57.6°$ INTO FOURTH QUADRANT)