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4 REM *****SPECTRUM*****
5 REM * ROBOT ARM SIMULATION*
6 REM *****SPECTRUM*****
10 CLS : PRINT "ROBOT ARM": PRINT : PRINT "THE
CONTROLS FOR THE ROBOT ARM ARE:"
15 PRINT "S- SELECT SHOULDER ROTATION": PRINT
"E- SELECT ELBOW ROTATION": PRINT "K-ROTATE JOINT
T CLOCKWISE"
20 PRINT "H-ROTATE JOINT ANTICLOCKWISE": PRINT
"U-GRAB BALL": PRINT "F-DROP BALL"
25 PRINT AT 20,1: FLASH 1:"hit a key": PAUSE
0: RANDOMIZE
1000 GO SUB 9500: REM init
1100 GO SUB 5000: REM input
1200 GO SUB 6000: REM crash
1400 STOP
1500 REM *update jointxy *****
1550 LET ex=11*SIN hd1: LET ey=11*COS hd1
1560 LET hx=ex+ex: LET hy=sy+ey
1650 LET wx=12*SIN hd2: LET wy=12*COS hd2
1660 LET hx=hx+wx: LET hy=hy+wy
1670 RETURN
2000 REM * draw arm *****
2020 INK acol
2050 PLOT INVERSE rubout;sx,sy
2100 DRAW INVERSE rubout;ex,ey: DRAW INVERSE r
ubout;wx,wy: IF bliup THEN LET br=FN r(hy): LET
bc=FN c(hx): GO SUB 2500
2490 RETURN
2500 REM * draw ball *****
2600 INK bcol
2650 PRINT AT br,bc: " (rubout+1)
2740 RETURN
2750 REM * drop ball *****
2800 LET rubout=1: GO SUB 2000: LET rubout=0
2820 LET k=INT (xh*RND): IF k>xs THEN IF k<=xs
+wd THEN GO TO 2820
2850 LET br=FN r(y0+4): LET bc=FN c(k): LET bliup
=0: GO SUB 2000: GO SUB 2500
2990 RETURN
3000 REM * rotate *****
3100 LET rubout=1: GO SUB 2000
3120 LET t1=dirn*sr*a1: LET t2=t1+dirn*er*a2
3150 LET hd1=hd1+t1: LET hd2=hd2+t2
3200 GO SUB 1500
3300 IF ABS hd1>p2 THEN LET ok=0
3320 LET pt=POINT (hx,hy)
3340 IF pt<>0 THEN LET ok=0: IF br=FN r(hy) AND
bc=FN c(hx) THEN LET ok=2
3400 LET rubout=0: GO SUB 2000
3450 INK bcol: PRINT AT 21,0;S;AT 21,2;FN d(hd
1);AT 21,2;FN d(hd2)
3490 RETURN
5000 REM * input *****
5100 IF INKEY<>"" THEN GO TO 5100
5120 FOR l=0 TO 1 STEP 0
5150 LET a$=INKEY$: IF a$="A" AND a$<="Z" THEN
LET a$=CHR$ (CODE a$+32)
5200 IF a$="s" THEN LET sr=1: LET er=0
5220 IF a$="e" THEN LET er=1: LET sr=0
5250 IF a$="k" THEN LET dirn=1: GO SUB 3000
5270 IF a$="h" THEN LET dirn=-1: GO SUB 3000
5300 IF a$="u" THEN IF ok=2 THEN LET bliup=1
5320 IF a$="f" THEN IF bliup THEN GO SUB 2750
5400 IF NOT ok THEN LET l=2
5450 NEXT l
5490 RETURN
6000 REM * crash *****
6100 PRINT AT 8,12: FLASH 1;"!!CRASH!!": BEEP .5
,-5: BEEP 1,-16: RETURN
9000 REM * draw base *****
9050 PAPER pacol: CLS
9100 INK grcol
9120 FOR k=0 TO y0: PLOT 0,k: DRAW xh,0: NEXT k
9200 INK bcol: LET xs=(xh-wd)/2
9220 FOR k=y0+1 TO y0+ht
9240 PLOT xs,k: DRAW wd,0
9260 NEXT k
9300 INK bcol: GO SUB 2500: INK acol
9400 PRINT AT 20,1;"SHOULDER":AT 20,2;"ELBOW"
9490 RETURN
9500 REM * init *****
9550 DEF FN d(x)=INT (x*100/PI)
9560 DEF FN r(x)=21-INT (x/8)
9570 DEF FN c(x)=INT (x/8)
9600 DIM s$(32): LET xl=0: LET yl=0: LET xh=254:
LET yh=174
9620 LET y0=23: LET wd=60: LET ht=23
9630 LET bliup=0: LET bc=2: LET br=FN r(y0+4)
9640 LET grcol=3: LET bcol=2: LET acol=1: LET b
col=6: LET pacol=7
9650 LET sx=xh/2: LET sy=y0+ht+2: LET l1=(yh-ht-
y0-2)/2: IF l1>xh/4 THEN LET l1=xh/4
9660 LET l2=l1: LET hx=0: LET hy=0
9670 LET p2=PI/2: LET a1=PI/32: LET a2=2*a1
9680 LET hd1=0: LET hd2=p2
9690 LET sr=1: LET er=0: LET dirn=1: LET rubout=
0: LET ok=1
9750 GO SUB 9000: GO SUB 1500: GO SUB 2000
9790 RETURN

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## Pick And Place

This program simulates a robot arm that is able to reach about, pick objects up and place them down in another location. Your task is simply to pick up the ball and then drop it. The arm is designed to use co-ordinates of revolution with two degrees of freedom: a shoulder joint and an elbow joint. The shoulder joint can rotate through 180° and the elbow joint through 360°.

The program is controlled using the following keys: S indicates that you want a shoulder movement; E indicates that you want an elbow movement; the K and H keys indicate whether you wish the joint of the arm to be rotated clockwise or anticlockwise. Each press rotates the shoulder joint through 6°, or the elbow through 12°. U indicates that you want the arm to attempt to pick up the ball. This will only be successful if you have managed to manipulate the arm within reach of the ball. F indicates that you want the robot to drop the ball



On the BBC Micro make the following additions and changes:

```

4 REM*****BBC*****
5 REM* ROBOT ARM SIMULATION *
6 REM*****BBC*****
7 MODE 1:COLOUR 130:COLOUR 1:CLS
25 PRINTTAB(15,20)"HIT A KEY":A$=GET$
1000 GOSUB 9600
2020 GCOL 0,acol
2050 MOVE sx,sy
2100 PLOT rubout,ex,ey:PLOT rubout,wx,wy:IF
bliup THEN br=hy:bc=hx:GOSUB 2500
2190 RETURN
2200 REM*****GRAB THE BALL*****
2250 bliup=1:rubout=3:GOSUB 2500
2300 rubout=1:GOSUB 2000
2600 GCOL 0,bcol:MOVE bc,br
2650 PLOT 0,0,bsz:PLOT 80+rubout,bsz,0
2700 PLOT 0,0,-bsz:PLOT 80+rubout,-bsz,0
2800 rubout=3:GOSUB 2000:rubout=1
2820 k=INT(xh*RND(1)):IF k>xs THEN IF k<=xs+wd
THEN GOTO 2820
2850 br=y0+5:bc=k:blup=0:GOSUB 2000:GOSUB 2500
3100 rubout=3:GOSUB 2000
3340 IF pt<>pacol-128 THEN ok=0:IF pt=bcol THEN
ok=2
3400 rubout=1:GOSUB 2000
3450 COLOUR bacol:PRINTTAB(0,3)S;TAB(4,3)FNd
(hd1);TAB(27,3)FNd(hd2)
5100 IF INKEY$(0)<>"" THEN GOTO 5100
5150 a$=INKEY$(0):IF a$="A"ANDa$<="Z"THENa$=CH
R$(ASC(a$)+32)
5300 IF a$="u" AND ok=2 THEN GOSUB 2200
5400 IF ok=0 THEN l=2
6100 PRINTTAB(12,3)"!!CRASH!!":SOUND 1,-15,48,1/
0:SOUND 1,-15,4,20:RETURN
9050 GCOL 0,pacol:COLOUR pacol:CLS
9100 GCOL 0,grcol
9120 FOR k=0 TO y0:MOVE 0,k:DRAW xh,k:NEXT k
9200 GCOL 0,bacol:xs=(xh-wd)/2
9240 MOVE xs,k:DRAW xs+wd,k
9300 MOVE bc,br:GOSUB 2500:COLOUR acol
9400 PRINTTAB(1,2)"SHOULDER":TAB(26,2)"ELBOW"
9600 s$="":xl=0:yl=0:xh=1000:yh=1000
9620 y0=100:wd=200:ht=100
9630 bliup=0:bsz=wd/5:bc=40:br=y0+5
9640 grcol=3:bacol=2:acol=2:bcol=0:pacol=129
9650 sx=xh/2:sy=y0+ht+2:l1=(yh-ht-y0-2)/2:IF l1
>xh/4 THEN l1=xh/4
9690 sr=1:er=0:dirn=1:rubout=1:ok=1

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### Straight From The Shoulder

Our robot arm simulation program allows you to move a two-joint arm in two dimensions and pick up an object with it. When the object is dropped the program places it randomly on the floor. The display shows the vertical angles made by the upper and lower arms