Assignment 1. ASTRONOMY 5500. 10 marks each.

1. For NGC 2281, the best parameters with $E_{B-B}/E_{B-V} = 0,77$ are (see graphs):

$E_{B-V} = 0.09 \pm 0.01$

$V - M_V = 8.70 \pm 0,05 \quad = 5 \log d - 5 + A_V$

$\therefore V_0 - M_V = 5 \log d - 5$

$V_0 - M_V = V - M_V - A_V = 8.70 - (3 \times 0.09)$

$= 8,70 - 0,27$

$= 8.43$

$\therefore d = 10^{(8.43+5)/5}$ pc

$= 485$ pc

$$\frac{\Delta d}{d} = \frac{\Delta (V - M_V)}{2,1714724} = \frac{\pm[(0.05)^2 + (0,03)^2]^{1/2}}{2,1714724} = \frac{\pm 0,0583095}{2,1714724}$$

$= \pm 0,0268531$

$\therefore \Delta d = \pm 0,0268531 \times 485$ pc

$= \pm 13$ pc.

i.e. $d = 485 \pm 13$ pc.

Hipparcos parallaxes yield (only 3 stars)

Star	π (mas)	$\Delta\pi$ (mas)	wgt $\left(\frac{1}{\Delta\pi^2}\right)$	$\pi \times$ wgt
1	1,63	1,24	0,6503642	1,0600937
2	4.10	1.66	0,3628973	1,4878792
3	0,91	1,40	0,5102040	0,4642857
		sum	1,5234657	3,0122586

$\therefore \pi$ (weighted) $= \frac{3,01\ldots}{1,52\ldots} = 1,9772409$ mas $\pm 0,810184$

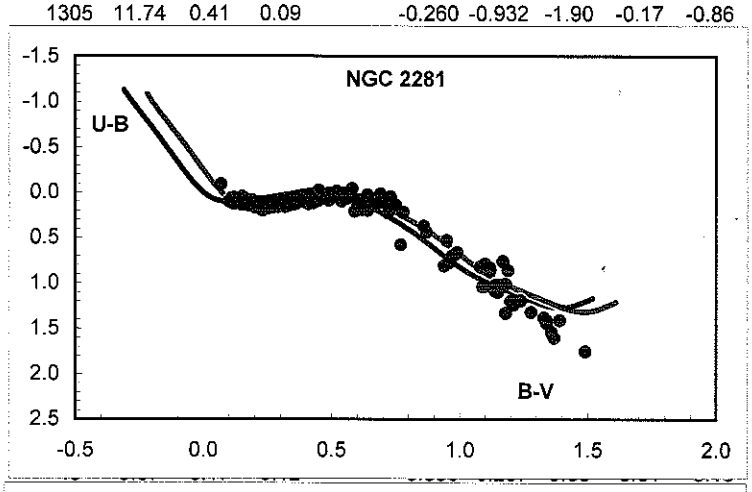
Gives $d = 1/\pi = 1/1.977\ldots$ pc $= 505,76$ pc $\pm 207,2$ pc (from $\frac{\Delta\pi}{\pi}$)

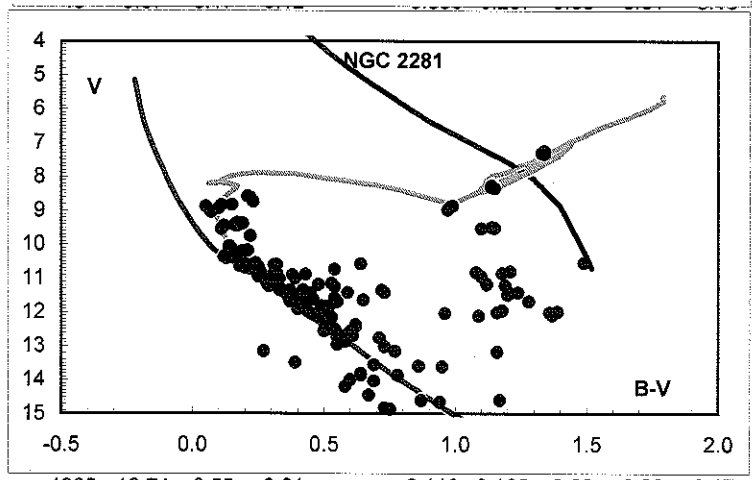
$d = 485 \pm 13$ pc (Zams fitting) versus 506 ± 207 pc (Hipparcos πs)

Zams gives more precise results, although both agree

RA=06 48 17 174.9
DC=+41 04 42 16.88
NGC 2281

Star	Ref.	V	B-V	U-B
5	1305	11.99	1.39	1.41
7	1305	11.74	0.41	0.09
42	1305	12.74	0.55	0.01
43	48	11.14	0.29	0.15
43	69	11.12	0.29	0.15
43	1305	11.24	0.29	0.13
44	48	10.86	0.26	0.16
44	69	10.84	0.26	0.15
44	1305	10.95	0.25	0.18
45	48	10.25	0.15	0.12
45	69	10.20	0.19	0.09
45	1305	10.34	0.15	0.12
46	48	11.70	0.55	0.04
46	1305	11.83	0.52	-0.01
48	48	11.73	0.42	0.08
48	69	11.75	0.40	0.12
48	1305	11.83	0.41	0.06
49	48	10.56	0.24	0.16
49	69	10.62	0.24	0.18
49	1305	10.66	0.25	0.16
50	48	11.17	1.12	0.86
50	69	11.22	1.19	0.86
50	1305	11.19	1.12	0.83
51	48	11.58	0.37	0.10
51	69	11.58	0.40	0.09
51	1305	11.69	0.37	0.10
52	48	10.91	0.38	0.09
52	69	10.89	0.43	0.08
52	1305	11.01	0.39	0.10
53	48	11.02	0.33	0.13
53	69	11.11	0.28	
53	1305	11.15	0.31	0.13
54	48	10.86	0.31	0.14
54	69	10.86	0.32	0.10
54	1305	10.96	0.32	0.16
55	48	8.89	0.98	0.69
55	69	8.87	0.99	0.66
55	1305	8.98	0.97	0.70





(B-V)o	(U-B)o	Mv	B-V	U-B	V
-0.310	-1.133	-3.50	-0.22	-1.06	5.20
-0.300	-1.089	-3.10	-0.21	-1.02	5.60
-0.290	-1.047	-2.70	-0.20	-0.98	6.00
-0.280	-1.008	-2.40	-0.19	-0.94	6.30
-0.270	-0.969	-2.13	-0.18	-0.90	6.57
-0.260	-0.932	-1.90	-0.17	-0.86	6.80
					7.00
					7.18
					7.35
					7.53
					7.70
					7.87
					8.05
					8.22
					8.38
					8.53
					8.67
					8.80
					8.93
					9.06
					9.19
					9.31
					9.43
					9.55
					9.65
					9.76
					9.85
					9.95
					10.04
					10.12
					10.20
					10.26
					10.31
					10.36
					10.41
					10.45
					10.49
					10.54
					10.59
					10.64
					10.69
					10.74
0.110	0.105	2.09	0.20	0.17	10.79
0.120	0.104	2.14	0.21	0.17	10.84
0.130	0.103	2.18	0.22	0.17	10.88
0.140	0.100	2.23	0.23	0.17	10.93
0.150	0.098	2.27	0.24	0.17	10.97
0.160	0.095	2.31	0.25	0.16	11.01
0.170	0.091	2.35	0.26	0.16	11.05
0.180	0.088	2.39	0.27	0.16	11.09
0.190	0.084	2.43	0.28	0.15	11.13
0.200	0.080	2.48	0.29	0.15	11.18
0.210	0.076	2.51	0.30	0.15	11.21
0.220	0.072	2.55	0.31	0.14	11.25
0.230	0.068	2.59	0.32	0.14	11.29
0.240	0.064	2.64	0.33	0.13	11.34
0.250	0.059	2.69	0.34	0.13	11.39
0.260	0.055	2.73	0.35	0.12	11.43
0.270	0.050	2.78	0.36	0.12	11.48
0.280	0.046	2.82	0.37	0.12	11.52
0.290	0.041	2.87	0.38	0.11	11.57
0.300	0.037	2.93	0.39	0.11	11.63
0.310	0.032	2.98	0.40	0.10	11.68
0.320	0.027	3.03	0.41	0.10	11.73
0.330	0.022	3.08	0.42	0.09	11.78
0.340	0.017	3.14	0.43	0.09	11.84
0.350	0.013	3.19	0.44	0.08	11.89
0.360	0.008	3.26	0.45	0.08	11.96
0.370	0.003	3.32	0.46	0.07	12.02
0.380	-0.002	3.39	0.47	0.07	12.09
0.390	-0.006	3.46	0.48	0.06	12.16
0.400	-0.010	3.52	0.49	0.06	12.22
0.410	-0.015	3.60	0.50	0.05	12.30
0.420	-0.018	3.68	0.51	0.05	12.38
0.430	-0.020	3.75	0.52	0.05	12.45
0.440	-0.021	3.82	0.53	0.05	12.52
0.450	-0.022	3.89	0.54	0.05	12.59
0.460	-0.022	3.96	0.55	0.05	12.66

Eb-v=	0.090	0.01	log t = 8.6
V-Mv=	8.70	0.05	
Vo-Mv	8.43		
d=	485		
pm	13		
Mv	-3.09		
dm-M	0.06		
S Sge			
V	5.614		
B	6.416		
U	6.983		
B-V	0.802		
U-B	0.567		
pm	8.38	0.923	
(B-V)o	0.7		
Ebv(B0)	-0.76		
Eb-v	0.102		
Vo	5.344		
Mv	-3.09		

B-V	Mv	B-Vred	Vred
1.70	-3.00	1.790	5.700
1.70	-2.84	1.790	5.860
1.65	-2.62	1.740	6.080
1.60	-2.47	1.690	6.230
1.57	-2.37	1.660	6.330
1.50	-2.18	1.590	6.520
1.45	-2.04	1.540	6.660
1.40	-1.83	1.490	6.870
1.35	-1.67	1.440	7.030
1.30	-1.45	1.390	7.250
1.25	-1.28	1.340	7.420
1.20	-1.04	1.290	7.660
1.15	-0.94	1.240	7.760
1.10	-0.74	1.190	7.960
1.05	-0.65	1.140	8.050
1.03	-0.52	1.120	8.180
1.00	-0.17	1.090	8.530
1.05	-0.24	1.140	8.460
1.10	-0.42	1.190	8.280
1.15	-0.62	1.240	8.080
1.20	-0.79	1.290	7.910
1.25	-1.00	1.340	7.700
1.30	-1.22	1.390	7.480
1.35	-1.58	1.440	7.120
1.30	-1.24	1.390	7.460
1.25	-1.09	1.340	7.610
1.20	-0.91	1.290	7.790
1.15	-0.73	1.240	7.970
1.10	-0.55	1.190	8.150
1.05	-0.40	1.140	8.300
1.00	-0.18	1.090	8.520
0.95	-0.02	1.040	8.680
0.90	0.16	0.990	8.860
0.85	0.08	0.940	8.780
0.80	-0.02	0.890	8.680
0.75	-0.12	0.840	8.580
0.70	-0.23	0.790	8.470
0.65	-0.31	0.740	8.390
0.60	-0.38	0.690	8.320
0.55	-0.43	0.640	8.270
0.50	-0.50	0.590	8.200
0.45	-0.55	0.540	8.150
0.40	-0.58	0.490	8.120
0.35	-0.65	0.440	8.050
0.30	-0.71	0.390	7.990
0.25	-0.72	0.340	7.980
0.20	-0.73	0.290	7.970
0.15	-0.74	0.240	7.960
0.10	-0.71	0.190	7.990
0.05	-0.63	0.140	8.070
0.00	-0.42	0.090	8.280
-0.03	-0.43	0.060	8.270
0.00	-0.46	0.090	8.240
0.05	-0.42	0.140	8.280
0.08	-0.34	0.170	8.360
0.05	-0.15	0.140	8.550
0.03	0.00	0.120	8.700
0.00	0.50	0.090	9.200
0.02	1.00	0.110	9.700
0.05	1.33	0.140	#####
0.10	1.83	0.190	#####
0.15	2.29	0.240	#####
0.20	2.50	0.290	#####

_r arcmin	_RAJ2000 deg	_DEJ2000 deg	HIP	RAhms	DEdms	Vmag mag	RA(ICRS) deg	DE(ICRS) deg	Plx mas	pmRA mas/yr	pmDE mas/yr	e_Plx mas	VTmag mag	B-V mag	d	unc	wgt	d x wgt
4.551	102.170206	41.066498	32654	06 48 40.85	+41 03 59.5	8.64	102.170218	41.0665167	1.63	-3.79	-7.79	1.24	8.616	0.214	613.5	466.71	1.728	1060.1
6.8415	101.995275	41.177132	32592	06 47 58.87	+41 10 37.7	10.25	101.995289	41.1771451	4.1	-4.24	-5.3	1.66	10.225	0.162	243.9	98.751	6.1003	1487.9
7.0141	102.092158	40.962527	32626	06 48 22.12	+40 57 45.2	8.86	102.092163	40.9625452	0.91	-1.46	-7.68	1.4	8.834	0.113	1098.9	1690.6	0.4225	464.29
																2256.1	8.2508	3012.3
															<d>	365.1		
															unc	44.2		

2. Hipparcos was able measure absolute parallaxes for stars with a precision of ±1 mas (milliarcsecond) typically. That is presumably how accurately Hipparcos can measure the instantaneous position of stars. But typical proper motions for the stars observed by Hipparcos are ~0,1 "/year to 1".0 /year, in some cases larger, some 100 – 1000 times larger than the position measurements. Provided that annual stellar aberration is taken into account, it means that Hipparcos should be able to measure very precise proper motions even with a limited time baseline of ~7 years. However, to be safe the mission also made use of the 50-100 years of position measures made by ground-based refractors prior to the mission. That assured a continuity of measures over a baseline of 50-100 years, thereby assuring highly precise proper motions for the observed stars. The accuracy of the measures should also be high, given the link to previous data.

3. Makarov's (2002) study makes use of Hipparcos Intermediate Astrometry Data, the same data set used by Hipparcos investigators to derive the stellar parallaxes in the final catalogue. The only difference with regard to parallaxes for Pleiades members is that Makarov restricted the number of comparison stars for each Pleiad to those lying within $58^\circ \pm 0.5$, rather than the larger interval of $58^\circ \pm 1.2$ used by the Hipparcos team. The reduction in comparison stars reduced the number of calculations needed to solve for the parallax, although the same techniques, or slight modifications from them, were adopted. The reduction in comparison stars used also greatly reduced the possibility of systematic errors affecting the data for the low-weight off-axis measures. Makarov's study is fairly convincing, despite van Leeuwen's (2005) critique, perhaps more so given that the new trigonometric parallax obtained for the Pleiades from cluster stars is very close to all other recent estimates based on photometry of the cluster and Zero-age main sequence (ZAMS) fitting.

4. The Hipparcos mission measured parallaxes primarily for stars brighter than $V = 10 - 11$, with some additional low precision results for fainter stars.

The U.S. Naval Observatory program required faint stars to attain high precision, and was also restricted to stars of measureable proper motion — generating an inherent bias in the results. As a result, the U.S. Naval Observatory program is restricted to nearby late-type dwarfs of $V > 11$. By comparison, Hipparcos measured bright stars of all luminosity classes without preselection by proper motion. There may be some bias in the results because it was a magnitude-limited survey, but that may be small (see Turner 2012).

In essence the two stellar samples measured by Hipparcos and the U.S. Naval Observatory are mutually exclusive, making any comparison impossible. But both cite similar precisions for their parallaxes, about ± 1 mas.