ATSC 201 2024
Total mark out of 50
Ch2: A5f, A13f, A15f.
Ch8: A12f, A13f, A18f, A19f
Ch10: A1f, A5f, A6b A8f.

Chapter 2

A5f) **Plot the local solar elevation angle vs. local time for 22 December, 23 March, and 22 June for the following city: f) Toronto, Canada**

(10.5 marks)

Given: The location Toronto, Canada
d (22-Dec) = 357 (leap year)
d (23-Mar) = 83 (leap year)
d (22-Jun) = 174 (leap year)
(also accept answers of DOY-1)

Find: Ψ (deg) = ?

Use eq. 2.5: $\delta s = \Phi r * \cos(C*(d - dr)/dy)$

where:	Φr =	0.40910518	rad
	C =	6.28318531	rad
	dr =	172	for 2024 (June 20th, but leap year)
	dy =	366	for 2024 (but 365 also acceptable)

	22-Dec	23-Mar	22-Jun
δs (rads)	-0.40886406	0.01755256	0.40886406
δs (deg)	-23.4261853	1.00568753	23.4261853

Use eq. 2.6: $\sin(\Psi) = \sin(\phi) * \sin(\delta s) - \cos(\phi)*\cos(\delta s)*\cos((C*tUTC/td)+\lambda e)$

where:	ϕ =	43.6532	degN=	0.761892069	rad
	λe =	-79.3832	degE=	-1.38549821	rad
	td =	24.0	h		

time zone of Montreal:

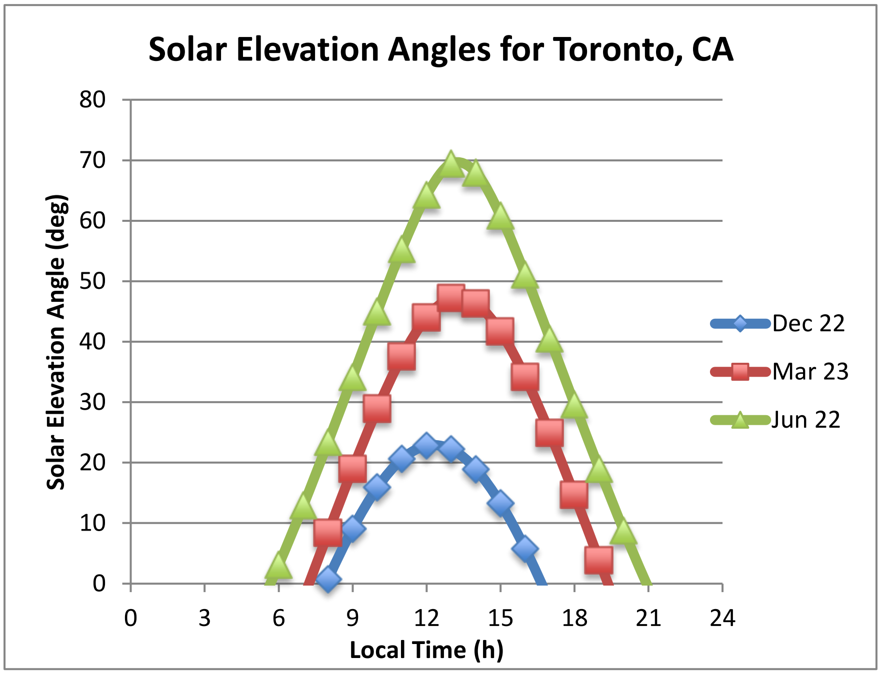
tUTC = t + 4 hours	EDT	(for Mar23 and Jun22)
tUTC = t + 5 hours	EST	(for Dec22)

HW3 Answer Key

	Ψ (deg)		
t(h)	**22-Dec**	**23-Mar**	**22-Jun**
0	-69.45	-42.09	-20.60
1	-67.97	-45.17	-22.80
2	-60.82	-44.34	-22.22
3	-51.11	-39.81	-18.92
4	-40.49	-32.48	-13.27
5	-29.65	-23.35	-5.77
6	-18.98	-13.18	3.10
7	-8.75	-2.47	12.93
8	0.72	8.36	23.38
9	9.08	18.96	34.16
10	15.87	28.89	44.96
11	20.60	37.53	55.32
12	22.80	43.99	64.25
13	22.22	47.17	69.45
14	18.92	46.32	67.97
15	13.27	41.64	60.82
16	5.77	34.14	51.11
17	-3.10	24.88	40.49
18	-12.93	14.61	29.65
19	-23.38	3.86	18.98
20	-34.16	-6.96	8.75
21	-44.96	-17.50	-0.72
22	-55.32	-27.31	-9.08
23	-64.25	-35.80	-15.87
24	-69.45	-42.09	-20.60

Check: Units ok. Physics ok.

Discussion: Toronto's winters luminosity is similar to Vancouver's winter luminosity



A13e) (2.5 marks)

Find the kinematic heat fluxes at sea level, given these regular fluxes (W/m^2): f) 500.

Given: **F**H = 500 W/m^2

Find: FH = ? K*m/s

Use eq. 2.11: FH = FH / rho*Cp
where rho *Cp = 1231 (W/m^2)/(K*m/s)

FH = 0.406173842 K*m/s

Check: Units ok. Physics ok.
Discussion: This amount of heat flux is just slightly higher than the advective heat flux of a 1m/s wind blowing air with a temperature excess of about 0.5C

A15f)
(5 marks)

Plot Planck curves for the following blackbody temperatures (K): f) 2000.

Given: T = 2000 K

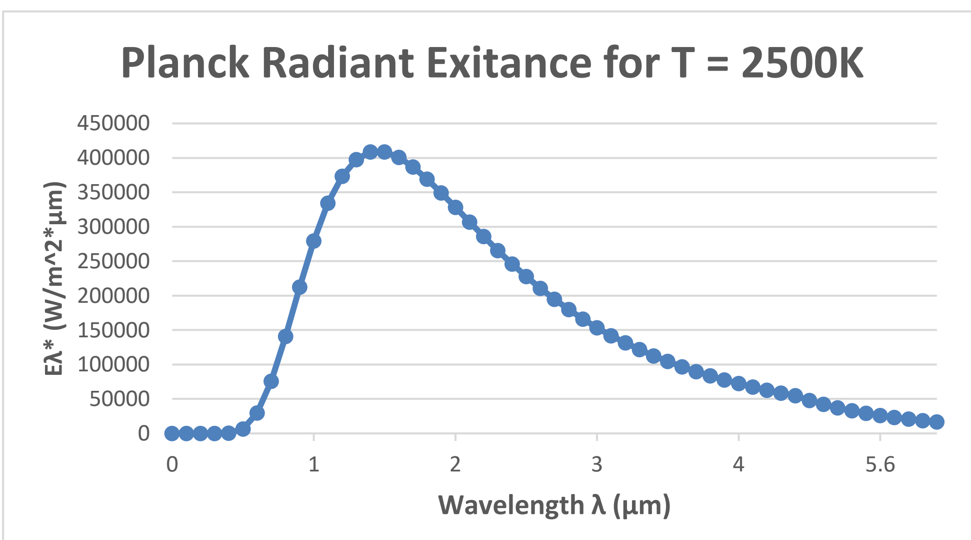
Find: Planck curve of blackbody object with temp T.

Use eq. 2.13: Eλ* = c1/(λ^5 *(e^(c2/λ*T)-1))

where c1 = 3.74E+08 W*µm^4/m^2
c2 = 1.44E+04 µm*K

λ (µm)	Eλ*
0	0
0.1	2.01E-18
0.2	2.71E-04
0.3	5.81E+00
0.4	5.56E+02
0.5	6.67E+03
0.6	2.96E+04
0.7	7.59E+04
0.8	1.41E+05
0.9	2.13E+05
1	2.79E+05
1.1	3.34E+05
1.2	3.73E+05
1.3	3.98E+05
1.4	4.09E+05
1.5	4.09E+05
1.6	4.01E+05
1.7	3.87E+05
1.8	3.69E+05
1.9	3.49E+05
2	3.28E+05
2.1	3.07E+05
2.2	2.86E+05
2.3	2.66E+05
2.4	2.46E+05
2.5	2.28E+05
2.6	2.11E+05
2.7	1.95E+05

2.8	1.80E+05
2.9	1.66E+05
3	1.54E+05
3.1	1.42E+05
3.2	1.31E+05
3.3	1.22E+05
3.4	1.13E+05
3.5	1.04E+05
3.6	9.68E+04
3.7	8.99E+04
3.8	8.35E+04
3.9	7.77E+04
4	7.23E+04
4.1	6.74E+04
4.2	6.29E+04
4.3	5.87E+04
4.4	5.48E+04
4.6	4.80E+04
4.8	4.22E+04
5	3.72E+04
5.2	3.29E+04
5.4	2.92E+04
5.6	2.59E+04
5.8	2.32E+04
6	2.07E+04
6.2	1.86E+04
6.4	1.67E+04



Check: Units ok. Physics ok.
Discussion: The temperature of this object
(2000K) is alomst the temperature of an incandescent light bulb
The peak wavelength is in the infrared range.

Chapter 8
A12f
3 marks

Find the range to a radar target, given the round-trip (return) travel times (μs) of: f) 75

Given:

t= 75 us = 7.50E-05 s

Find: range of radar target

Use eq. 8.16 R= c*t/2

c= 3.00E+08 m/s

R= 1.13E+04 m

Check: Units ok. Physics ok.
Discussion: The radar target is slightly farther than
10km which only requires a round-trip time of 75 us
since radar pulses travel at the speed of light.

A13f
2.5 marks

Find the radar max unambiguous range for pulse repetition frequencies (s–1) of: f) 800

Given:
PRF= 800 s-1

Find: maximum unambiguous range

Use eq. 8.17 Rmax=c/(2*PRF)

c=	3.00E+08	m/s
Rmax=	1.88E+05	m

Check: Units ok. Physics ok.

Discussion: The radar's max unambiguous range is 188km which puts it in the C band

A18f

7 marks

> For a radar with 0.5° elevation angle mounted on a 10 m tower, calculate and plot the height of the radar-beam centerline vs. range from 0 to 500 km, for the following beam curvature factors ke, and name the type of propagation: f) 1.5

Given:

ke=	1.5				
z1=	10	m			
ψ=	0.5	°	=	0.00872665	rad
Ro=	6371	km	=	6371000	m

Find: height of radar-beam centerline

Use eq. 8.21 Rc=Ro*ke

Rc= 9556500 m

Use eq. 8.22 z=z1-Rc+sqrt(R^2+Rc^2+2*R*Rc*sin(ψ))

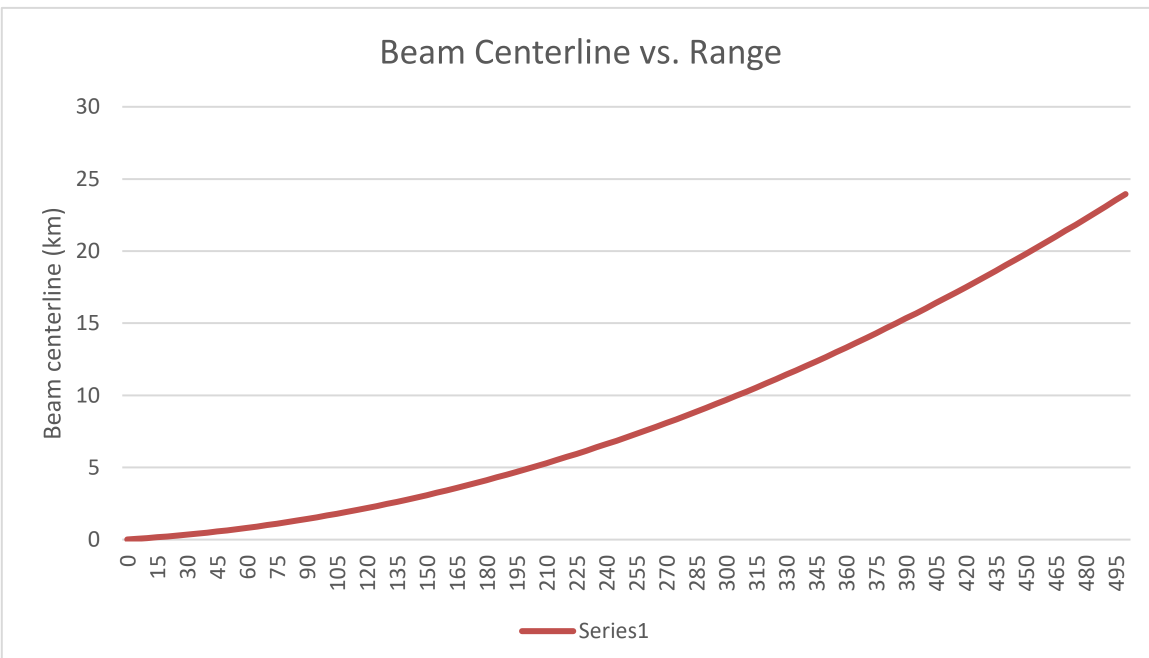
R (km)	R (m)	z (m)	z (km)
0	0	10	0.01
5	5000	55.59452972	0.05559453
10	10000	105.1127065	0.10511271
15	15000	158.554439	0.15855444
20	20000	215.9196283	0.21591963
25	25000	277.2081685	0.27720817

HW3 Answer Key

30	30000	342.4199464	0.34241995
35	35000	411.5548415	0.41155484
40	40000	484.6127261	0.48461273
45	45000	561.5934652	0.56159347
50	50000	642.4969168	0.64249692
55	55000	727.3229313	0.72732293
60	60000	816.0713521	0.81607135
65	65000	908.7420153	0.90874202
70	70000	1005.33475	1.00533475
75	75000	1105.849377	1.10584938
80	80000	1210.285712	1.21028571
85	85000	1318.643561	1.31864356
90	90000	1430.922725	1.43092272
95	95000	1547.122995	1.547123
100	100000	1667.244159	1.66724416
105	105000	1791.285993	1.79128599
110	110000	1919.24827	1.91924827
115	115000	2051.130752	2.05113075
120	120000	2186.933197	2.1869332
125	125000	2326.655354	2.32665535
130	130000	2470.296965	2.47029697
135	135000	2617.857765	2.61785777
140	140000	2769.337482	2.76933748
145	145000	2924.735837	2.92473584
150	150000	3084.052543	3.08405254
155	155000	3247.287305	3.24728731
160	160000	3414.439824	3.41443982
165	165000	3585.509791	3.58550979
170	170000	3760.49689	3.76049689
175	175000	3939.4008	3.9394008
180	180000	4122.221189	4.12222119
185	185000	4308.957722	4.30895772
190	190000	4499.610054	4.49961005
195	195000	4694.177834	4.69417783
200	200000	4892.660704	4.8926607
205	205000	5095.058297	5.0950583
210	210000	5301.370242	5.30137024
215	215000	5511.596157	5.51159616
220	220000	5725.735657	5.72573566
225	225000	5943.788346	5.94378835
230	230000	6165.753823	6.16575382

235	235000	6391.631681	6.39163168
240	240000	6621.421502	6.6214215
245	245000	6855.122865	6.85512287
250	250000	7092.735339	7.09273534
255	255000	7334.258487	7.33425849
260	260000	7579.691865	7.57969187
265	265000	7829.035022	7.82903502
270	270000	8082.287499	8.0822875
275	275000	8339.44883	8.33944883
280	280000	8600.518543	8.60051854
285	285000	8865.496159	8.86549616
290	290000	9134.381189	9.13438119
295	295000	9407.173141	9.40717314
300	300000	9683.871512	9.68387151
305	305000	9964.475795	9.9644758
310	310000	10248.98548	10.2489855
315	315000	10537.40003	10.5374
320	320000	10829.71893	10.8297189
325	325000	11125.94164	11.1259416
330	330000	11426.06761	11.4260676
335	335000	11730.09629	11.7300963
340	340000	12038.02714	12.0380271
345	345000	12349.85957	12.3498596
350	350000	12665.59303	12.665593
355	355000	12985.22692	12.9852269
360	360000	13308.76067	13.3087607
365	365000	13636.19369	13.6361937
370	370000	13967.52536	13.9675254
375	375000	14302.75509	14.3027551
380	380000	14641.88227	14.6418823
385	385000	14984.90626	14.9849063
390	390000	15331.82645	15.3318264
395	395000	15682.64219	15.6826422
400	400000	16037.35286	16.0373529
405	405000	16395.95778	16.3959578
410	410000	16758.45632	16.7584563
415	415000	17124.84781	17.1248478
420	420000	17495.13158	17.4951316
425	425000	17869.30695	17.869307
430	430000	18247.37324	18.2473732
435	435000	18629.32975	18.6293298

440	440000	19015.1758	19.0151758
445	445000	19404.91067	19.4049107
450	450000	19798.53365	19.7985337
455	455000	20196.04404	20.196044
460	460000	20597.44109	20.5974411
465	465000	21002.72407	21.0027241
470	470000	21411.89226	21.4118923
475	475000	21824.9449	21.8249449
480	480000	22241.88124	22.2418812
485	485000	22662.70052	22.6627005
490	490000	23087.40198	23.087402
495	495000	23515.98483	23.5159848
500	500000	23948.44831	23.9484483



Propagation type: subrefraction

Check: Units ok. Physics ok.

Discussion: The beam centerline height increases
as the range increases which indicates subrefraction
which is typical of an unstable atmosphere

A19f
3 marks

Use the simple Z-R relationship to estimate the rainfall rate and the descriptive intensity category used by pilots and air traffic controllers, given the following observed radar echo dBZ values: f) 48

Given:

dBZ= 48 dBZ

Find: Rainfall rate and descriptive intensity

Use eq. 8.29 a1*10^(a2*dBZ)

a1= 0.017 mm/hr
a2= 0.0714 dBZ-1

RR= 45.46204017 mm/hr

Precipitation category: heavy

Check: Units ok. Physics ok.
Discussion: This rainfall rate is considered heavy
which would significantly reduce visibility for pilots.

Chapter 10

A1f)
(3 marks)

Plot the wind symbol for winds with the following directions and speeds: f) SW at 105kt.

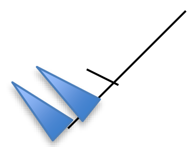
Given: M = 48 kt
direction = S

Find: Applicable wind symbol.

From Table 10-1:

Pennant	50 speed units
half-barb	5 speed units

105 kt = 2 pennants and 1 half-barb



Check: direction and symbol ok.

Discussion: If only the pressure gradient force was acting here, high pressure would be to the SW and low pressure would be to the NE

A5f)

(4 marks)

Town A is 500km west of town B. The pressure at town A is given below, and the pressure at town B is 100.1kPa. Calculate the pressure-gradient force/mass in between these two towns: f) 99.6 kPa.

Given:	Δx =	500	km
	P@A =	99.6	kPa
	P@B =	100.1	kPa

Find:	FxPG/m =	?	m/s^2
	FyPG/m =	?	m/s^2

Use eq. 10.9a: FxPG/m = -(1/ρ)*(ΔP/Δx)

where ρ = 1.2 kg/m^3

Convert Δx(km) to Δx(m):

Δx = 500000 m

Convert P@A(kPa) to P@A(Pa) and P@B(kPa) to P@B(Pa):

P@A =	99600	Pa
P@B =	100100	Pa
ΔP =	500	Pa

Since town A is 500km to the west of town B, there is no pressure change in the North - South direction.

FxPG/m = -0.00083333 m/s^2

Check: Units ok. Physics ok.
Discussion: The PGF is negative because air flows east to west from town B to town A. The force is very small because the pressure difference is very small.

A6b)
(5.5 marks)

Suppose that U = 8m/s and V = -3 m/s, and latitude = 45 deg. Calculate centrifugal force components around a: b) 900km radius high in N. hemisphere

Given:	U =	8	m/s
	V =	-3	m/s
	lat =	45	degN
	R =	900	km

Find:	FxCN/m =	?	m/s^2
	FyCN/m =	?	m/s^2

Use eq. 10.13a: FxCN/m = +s *(V*M)/R
Use eq. 10.13b: FyCN/m = -s *(U*M)/R

where M = (U^2 + V^2)^1/2

North Hemisphere, high pressure:
s= -1

Convert R(km) to R(m):
R = 900000 m

M = 8.54400375 m/s

FxCN/m = 2.848E-05 m/s^2
FyCN/m = 7.59467E-05 m/s^2

Check: Units ok. Physics ok.
Discussion: These components correspond to a force pointing SSW.

A8f)

(4 marks)

What is the magnitude and direction of Coriolis force/mass in Los Angeles, USA, given: f) U(m/s) = -5, V(m/s) = 0.

Given:	U =	-5	m/s	
	V =	0	m/s	
	lat =	34.0522	degN	of Los Angeles, USA

Find: |FCF/m| = ? m/s^2
Direction of FCF/m.

Use eq. 10.18a: |FCF/m| = 2*Ω*|sin(ϕ)*M|
or
use eq. 10.18b: |FCF/m| = |fc*M|
and eq. 10.16: fc = 2*Ω*sin(ϕ)

where M = (U^2 + V^2)^1/2
M = 5 m/s
and
Ω = 7.29E-05 s^-1

|FCF/m| = 4.08E-04 m/s^2
Direction is towards the North

Check: Units ok. Physics ok.
Discussion: The force is 90° to the wind's right in the N.H so the coriolis force will be towards the North, since the observed wind is easterly.