ATSC 201 Fall 2023
Chapter 1: A7e, A10b, A11e, A12e
Chapter 8: A10e, A11, A12d, A13d, A18d, A19d
Total mark out of 35

Chapter 1:

A7e) (3 marks)

Find the virtual temperature (degC) for air of
e) T(degC) = 50, r(g/kg) = 60.

Given: T = 50 degC
r = 60 g/kg

Find: Tv = ? degC

Using: Tv = T * (1 + (a*r)) eq. 1.21
where a = 0.61 g/g dryair/watervapor

Convert T to Kelvins:
T(K) = T(degC) + 273.15
T = 323.15 K

Convert r to g/g:
r(g/g) = r(g/kg) * (1kg/1000g)
r = 0.06 g/g

Tv =	**334.97729 K**
	61.82729 degC

Check: Units ok. Physics ok.
Discussion The virtual temperature is more than 10degC higher than the actual temperature. The moisture in the air is having a large effect.

A10b) (3 marks)

What is the temperature (°C) of air, given
b) P = 90 kPa and ρ = 1.0 kg·m–3 ?

Given: P = 90 kPa
ρ = 1 kg*m^-3

Find: T =

Using: T = P/(ρ*Rd)
where Rd = 0.286053 kPa*K^-1 * m^e * kg^-1

T =	314.62701 K
T (degC) =	41.4770097 degC

Check: Units ok. Physics ok.
Discussion: BC reached 40 deg C for the first time ever recorded in 2023

A11e) (3 marks)

At a locationin the atmosphere where the air density is 1 kg/m^3 find the change of pressure (kPa) you would feel if your altitude increases by 11km.

Given: rho = 1 kg/m^3
Δz = 11 km

Find: ΔP = ? kPa

Using: ΔP = rho * g * Δz eq. 1.25a
where g = -9.8 m/s^2

Convert Δz to m:
Δz (m) = Δz (km) * 1000
Δz = 11000 m

ΔP =	**-107800 Pa**
	-107.8 kPa

Check: Units ok. Physics ok.
Discussion If 1 atm = 101.325 kPa, an increase in altitude of 11km causes a loss of more than 1 atm of pressure.

A12e) (3 marks)

At a location in the atmosphere where the average virtual temperature is 5 degC, find the height difference (ie. The thickness in km) between the following two pressure levels (kPa): 60, 50.

Given: P1 = 60 kPa
P2 = 50 kPa
avg Tv = 5 degC

Find: Δz = z2-z1 = ? km

Using: $\Delta z = z2 - z1 = a * Tv * \ln(P1/P2)$ eq. 1.26a

where a = 29.3 m/K

Convert Tv into Kelvins:

Tv (K) = Tv (degC) + 273.15

Tv = 273.15 K

$\Delta z = z2-z1$:	**1459.17**	**m**
	1.46	**km**

Check: Units ok. Physics ok.

Discussion Because of the log profile, the thickness between pressure levels expands higher in the atmos.

Chapter 8:

A10e) (3 marks)

Find the beamwidth angle for a radar pulse for the following sets of [wavelength (cm), antenna dish diameter (m)]: e) [10, 3].

Given: λ = 10 cm

d = 3 m

Find: $\Delta\beta$ = ? deg

Using: $\Delta\beta = a*\lambda / d$ eq. 8.13

where a = 71.6 deg

Convert d to cm:

d (cm) = d (m) * 100

d = 300 cm

$\Delta\beta$ =	**2.39**	**deg**

Check: Units ok. Physics ok.

Discussion The antenna dish diameter is fairly small, so the beamwidth is larger.

A11) (2 marks)

What is the name of the radar band associated with the wavelengths of the previous exercise? λ = 10 cm

Given: λ = 10 cm

Find: Name of radar band for λ

From p.242 in Stull (2011), wavelengths λ between 7.5cm and 15cm are designated as in the: S band.

Check: Units ok. Physics ok.
Discussion Must have an antenna dish diamter of at least 9m to enable long range detection capabilities.

A12e) (3 marks)

Find the range to a radar target, given the round-trip (return) travel times (μs) of: e) 50.

Given: t = 50 μs

Find: R = ? m

Using: R = c*t / 2 eq. 8.16
where c = 3.00E+08 m/s

Convert t to s:
t (s) = t (μs) * 10^-6
t = 5.00E-05 s

R = 7500 m

Check: Units ok. Physics ok.
Discussion In a fraction of a second the beam has traveled over 7km.

A13e) (2.5 marks

Find the radar max unambiguous range for pulse repetition frequencies (s^-1) of: e) 600.

Given: PRF = 600 /s

Find: Rmax = ? m

Using: Rmax = c/ (2*PRF) eq. 8.17
where c = 3.00E+08 m/s

Rmax =	**250000**	**m**

Check: Units ok. Physics ok.

Discussion The higher the pulse repetition frequency, the larger Rmax is.

A18e)
(9 marks)

For a radar with 0.5deg elevation angle mounted on a 10m tower, calculate and plot the height of the radar-beam centerline vs. range from 0 to 500km, for the following beam curvature factors ke, and name the type of propagation: e) 1.33

Given: Ψ = 0.5 deg
z1 = 10 m
R = 0 - 500 km

Find: z = ? km

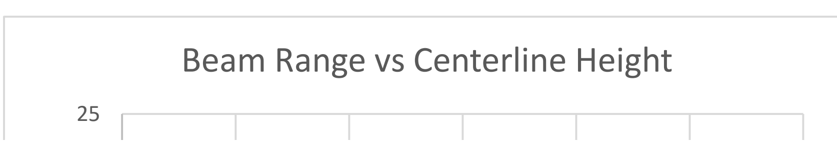
Using: Rc = ke * Ro eq. 8.21
where ke = 1.33
Ro = 6371 km

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

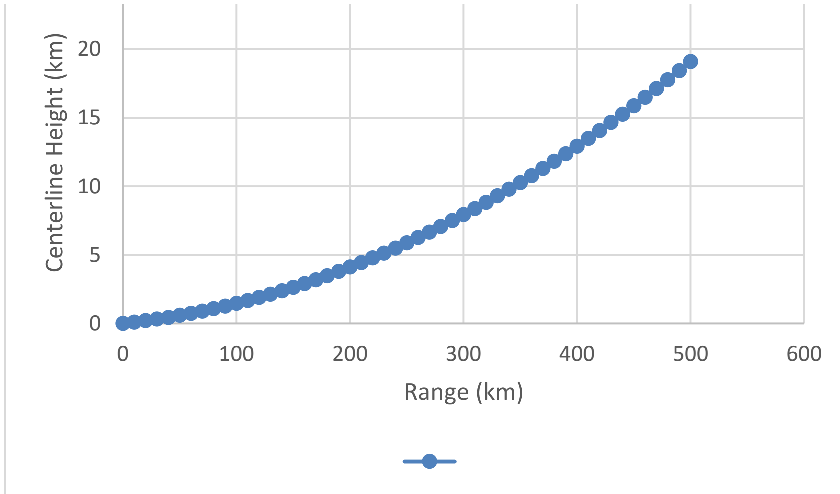
Convert z1(m) to z1(km):
z1 (km) = z1 (m) /1000
z1 = 0.01 km

Rc =	8473.43	km

Range, R (km)	**Height of beam center, z (km)**	
0	0.01	1 mark for correct z values
10	0.103166	(ok if different increments as long as reasonable)
20	0.208132	
30	0.324897	
40	0.453463	
50	0.593827	
60	0.745989	
70	0.909949	
80	1.085706	
90	1.273259	



100	1.472607
110	1.68375
120	1.906687
130	2.141416
140	2.387938
150	2.64625
160	2.916352
170	3.198242
180	3.49192
190	3.797383
200	4.114632
210	4.443664
220	4.784479
230	5.137074
240	5.501449
250	5.877601
260	6.26553
270	6.665233
280	7.076709
290	7.499956
300	7.934973
310	8.381757
320	8.840308
330	9.310622
340	9.792698
350	10.28653
360	10.79213
370	11.30948
380	11.83858
390	12.37943
400	12.93204
410	13.49639
420	14.07248
430	14.66032
440	15.2599
450	15.87121
460	16.49426
470	17.12904
480	17.77555
490	18.43379
500	19.10375



Check: Units ok. Physics ok.

Discussion:

To determine the radar propagation type, re-arange eq. 8.21 to find ΔN/Δz

Δn/Δz = (1/Rc) - (1/Ro)

Δn/Δz =	-3.9E-05	/km
ΔN/Δz =	-38.945268	/km

Table 8-7 for ΔN/Δz between 0 and -79 km^(-1):

The type of propagation is called **normal range**.

A19d)
(3.5 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: e) 58

Given:	reflectivity =	58	dBZ
Find:	RR =	?	mm/hr
	intensity category		
Using:	RR = a1*10^(a2*dBZ)		eq. 8.29
	where a1 =	0.017	mm/hr
	a2 =	0.0714	/dBZ

From Fig. 8.28, intensity category for 45 dBZ is:
Heavy

RR = 235.314626 mm/hr

Checks: Units ok. Physics ok.
Discussion 27 mm of rain in 1 hour is quite a lot.
This would rarely happen in Vancouver.