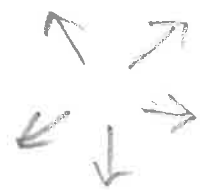
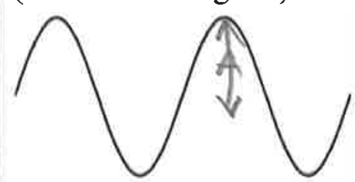
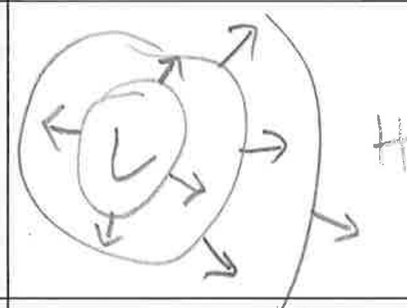
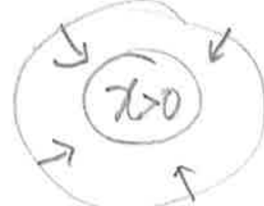
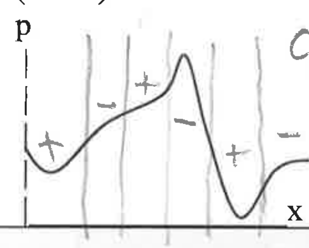
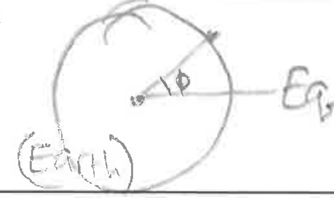
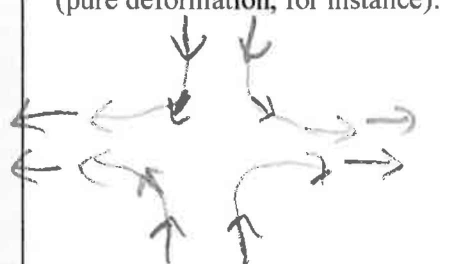
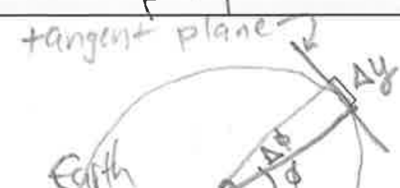
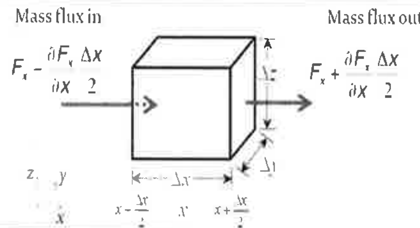
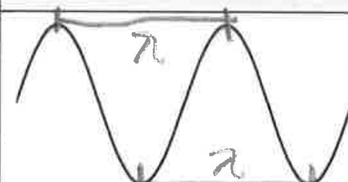
ATM 651 Midterm Exam: vocabulary. Name Key

Fill in the white boxes, 2 points each. *gray box: no response asked*

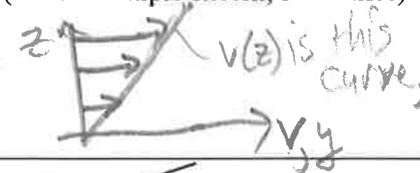
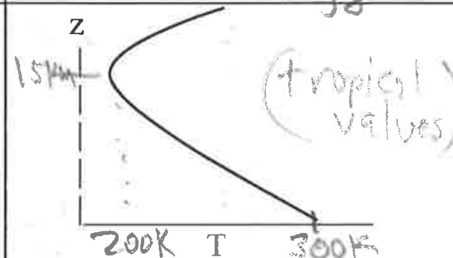
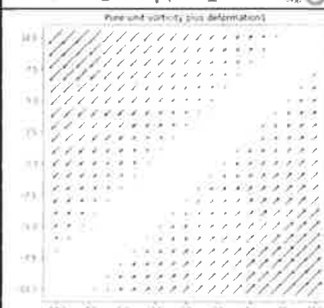
Words/name	**Symbol**	**Units**	**Math definition or concept (explain)**	**Relevant sketch** or extra space for more words
speed of wind whose components are u(x,y), v(x,y)		m/s	(formula from u&v): $\sqrt{u^2+v^2}$	
curl operator		m^{-1}	(use nabla): $\nabla\times$	Just the operator (or operation). It has units.
vector velocity *field* of pure divergence	$V_{div}(x,y)$	m/s		
Amplitude of a wave	A	(depends on wave of what)	indicate on sketch	(indicate on diagram) 
Gradient of p(x,y) where p is sea level pressure on a weather map	∇p	$\frac{Pa}{m}$	sketch some contours with H and L, & indicate vectors that illustrate concept	
velocity potential of a divergent 2D horizontal flow ($\vec{V} = \nabla\chi$) as in HW1	$\chi(x,y)$	$\frac{m^2}{s}$	sketch contours and a few velocity vectors -->	
vertical advection of meridional momentum	$-\omega\frac{\partial v}{\partial p}$	m/s^2	rate of change of v due to advection by vertical wind component	I mean *specific momentum* of course, momentum per unit mass

3d Wind	**V**	m/s	**i**u+**j**v+**k**w	
total (Lagrangian) tendency of q (specific humidity)	$\frac{d\vec{V}}{dt}$	$\frac{m}{s^2}$		
Coriolis *parameter*	f	s^{-1}	$2\Omega\sin\phi$	
vertical velocity	w *(or ż)*	m/s		careful! w is a humidity measure in another W&H chapter
planetary Boundary Layer	PBL		the layer of air in contact w/ the surface	(how tall, typically?) ~1 km
horizontal advection of specific humidity q	$-\vec{V}_h \cdot \vec{\nabla} q$	$\left(\frac{kg_w/kg_{air}}{s}\right)$	(both components, or vector form)	is q "dimensionless"? **No**, kg_{water}/kg_{air}
"Laplacian" in one dimension of p(x)	second derivative	curvature	(use d not ∂, because *p is a function of one variable only)*: $\frac{d^2p}{dx^2}$	Indicate regions of each sign (+ or -) and their boundaries:  curvature
planetary vorticity	f	s^{-1}		
(dead white guy's name): Laplacian	divergence of the gradient of Z(x,y)	$\frac{m}{m^2}$	$\nabla^2 Z$	here Z is geopotential height
		m/s	north-easterly wind	 from NE
Mass of 1 cc = 1 ml of water, in MKS units		10^{-3} kg	1 m³ of water is the kg	← explain from MKS essentials
latitude	ϕ (a scalar coordinate)	deg or radians	Latitude is an *angle* from the center of the Earth.	sketch 

meridional flux of *zonal momentum* vu	with density factor, or without, either is fine	m^2/s^2 vu	(words about what a flux is): transport (its convergence is a transport tendency)	Positive for southwesterly wind, negative for northeasterly wind.
vector velocity of a baseball in x,y,z coordinates	**V**	m/s	(use $\dot{x}, \dot{y}, \dot{z}$ and ***i, j, k***): $\hat{i}\dot{x}+\hat{j}\dot{y}+\hat{k}\dot{z}$	Overdot is Newton's time derivative notation, $\dot{x}$ = dx/dt
del operator	∇	m^{-1}	$\hat{i}\frac{\partial}{\partial x}+\hat{j}\frac{\partial}{\partial y}+\hat{k}\frac{\partial}{\partial z}$	A sum of 3 terms. Write **i,j,k** to the *left of derivatives* since things on the right of the derivative get *operated on, not multiplied*
temperature	T(x,y,z,t)	K	a measure of energy of molecular motion ("heat")	History of unit? Water, Earth? $\frac{(\text{boil} - \text{freeze})}{100}$ H_2O @ mean SLP on Earth
Coriolis force (per unit mass)	$f\vec{V}\times\hat{k}$	m/s^2		a *vector*, like all forces
A flow field with curvature but not vorticity. Sketch as vectors, threaded with streamlines.	Remember, arrows for vectors apply at their tail, length is proportional to speed.			(pure deformation, for instance): 
horizontal convergence of horizontal flux of specific humidity q	$-\vec{\nabla}_h\cdot\rho q\vec{V}_h$	$\frac{\partial(\rho q)}{\partial t} = \frac{kg_{H_2O}/m^3}{s}$	OK if ρ was omitted (or divided)	Hey, does it mean anything that $\vec{\nabla}$ is sometimes written with/without an arrow over it? No, it is just one thing. $-\frac{1}{\rho}\nabla\cdot(\rho q\vec{V}) = \left(\frac{kg_w/kg_a}{s}\right)$
PGF	$-\vec{\nabla}\Phi$	m/s^2	$-\vec{\nabla}\Phi$ or	Xyz or xyp coordinates, your choice $-\frac{1}{\rho}\vec{\nabla}p$
distance north from origin	y (Cartesian coordinate used similar to latitude)		distance on a tangent plane, in the direction of **j** unit vector	

vertical component of vector vorticity	ζ	s^{-1}	(use nabla & **k**): $\hat{k}\cdot\vec{\nabla}\times\vec{V}$	
Gradient of Φ(x,y,t) (Φ = gZ)	units in cell to right →	m/s^2	$\hat{i}\frac{\partial\Phi}{\partial x} + \hat{j}\frac{\partial\Phi}{\partial y}$	use **i,j,~~k~~** (Cartesian unit vectors) to express it in the math cell at left. Φ is the *geopotential*.
Convergence of mass flux (express it in our usual way involving **V**)	(math): $-\vec{\nabla}\cdot(\rho\vec{V})$ $\frac{\partial\rho}{\partial t}$ = this	(units): $\frac{\frac{kg}{m^3}\cdot\frac{m}{s}}{m}$ $= kg\,m^{-3}s^{-1}$	(labeled in the diagram as **F**, but express it in our usual way w/ **V**)	
Energy flux (like an *irradiance* or *insolation*)	$E = mV^2/2$ flux is $E/m^2/s$	(Use Joule or Watt names): W/m^2	(Units in basic m,kg,s): $\frac{kg\,m^2/s^2}{s\cdot m^2}$ $= kg\,s^{-3}$	How much (energy) passing through a plane, per unit area per second
Radius of earth in MKS units	6340? a $= \frac{2}{\pi}\times10^4$ m	$2\pi r = 4\times10^4$ m	(Eq-Pole distance)/10^4 = meter	←How is it related to the original definition of the meter?
circulation	C	$\frac{m^2}{s}$	$\oint V\cdot dl = \iint \zeta\, dA$	Area integrated vorticity, or line integral of velocity, your choice: actually, write both (that is, write Stokes' theorem)! and its units
wavelength	λ	m	a measure about a *spatial* sinusoid -->	
confluence without convergence			sketch --> carefully (streamlines and isotachs)	
dot product of a force and velocity	(physics word): work	$kg\cdot m/s^2 \times (m/s) = (kg\,m^2/s^2)/s$ = watts = J/s	$\vec{F}_{\square}\cdot\vec{V}$	Remember that force times displacement is energy. Think of a descending object for instance, gravity acting on it

BOX TOO SMALL!

Local or Eulerian tendency of T(x,y,p,t)	$\left.\frac{\partial T}{\partial t}\right\|_{x,y,p}$	$\frac{K}{s}$		write it in a form making clear *what is held constant* in the partial derivative
Laplacian of T(x,y,t)	(use nabla): $\nabla^2 T$	$\frac{K}{m^2}$		
vertical shear of meridional wind		$\frac{m/s}{m} = s^{-1}$	$\partial v/\partial z$	(make a simple sketch, label axes):  or vectors(v) are the wind profile
troposphere the layer of air that radiation cools, so that surface solar heating must warm it with weather motion	how deep?	put some typical values on axes		
shear	One part pure vorticity, plus one part pure deformation	Units s^{-1}		
Meridional advection of temperature		Units $\frac{K}{s}$	Math $-v\frac{\partial T}{\partial y}$	
omega	ω	Pa/s	$\dot{p}$, vertical velocity of air in p coord.	(which sign is upward vs. downward motion?) negative positive
Scalar or vector field? Scalar field	$-\nabla \cdot \nabla u$ $-\nabla^2 u$	$\frac{m/s}{m^2}$		What can you say about its properties, or its role in *diffusion*? diffusion is down-gradient transport $-K\nabla u$. Its convergence (transport tendency) is $-\nabla \cdot K\nabla u = -K\nabla^2 u$.
Advective tendency of v	$-\vec{V}\cdot\vec{\nabla} v$	m/s^2	$-\vec{V}\cdot\vec{\nabla} v$	Tendency of v due to upwind v being different

Part II: write the Primitive Equations in this grid, one term per box:

	A	B	C	D	E	F	G
1. mass continuity	0	$= \frac{\partial u}{\partial x}$	$+ \frac{\partial v}{\partial y}$	$+ \frac{\partial \omega}{\partial p}$			
2. zonal wind component (**any form you like**)	$\frac{du}{dt}$	$= -\frac{\partial \Phi}{\partial x}$	$+fv$	$+ F_x$			
3. meridional (write **advection on RHS in xyp coords w/ no vectors**)	$\frac{\partial v}{\partial t}$	$= -u\frac{\partial v}{\partial x}$	$- v\frac{\partial v}{\partial y}$	$-\omega\frac{\partial v}{\partial p}$	$-\frac{\partial \Phi}{\partial y}$	$-fu$	$+F_y$
4. hydrostatic balance	$\frac{\partial \Phi}{\partial p}$	$= -\frac{RT}{p}$					
5. First Law for T	$\frac{\partial T}{\partial t}$	$= -\vec{V}_h \cdot \vec{\nabla} T$	$- \omega\frac{\partial T}{\partial p}$	$+ \frac{\alpha}{C_p}\frac{dp}{dt}$	$+ J/C_p$		

we didn't study this, any of constant is fine... more to come...

Which box or row contains each of the following:

1. the force of gravity along a pressure surface 3E, 2B
2. zonal advection of meridional momentum 3B
3. horizontal convergence of wind 1B+1C
4. thickness of a pressure layer 4A = 4B
5. radiative heating rate 5E
6. latent (condensational) heating rate 5E
7. adiabatic compression warming 5D
8. Coriolis force (two boxes) 2C, 3F
9. F=ma in the vertical direction Eq. 4
10. slope of a pressure surface 3E, 2B (same as 1. I guess)