Astronomy 25
Useful Equations
Second half of semester

Heisenberg Uncertainty principle
$\Delta x \Delta p \geq \hbar/2$
-or-
$\Delta E \Delta t \geq \hbar/2$, where $\hbar = h/2\pi$

Circular velocity
$v_c^2 = GM/R$

Virial cluster mass
$M_{cluster} = 5Rv^2_{average}/G$

Thermal energy per atom
$E_{KE} \approx kT$
-where-
$k = 1.38\times10^{-23}$ J/K
k = Boltzmann constant

Einstein's Field Equations
$G_{\mu\nu} = (8\pi G/c^4)T_{\mu\nu}$
-or-
$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R + g_{\mu\nu}\Lambda = (8\pi G/c^4)T_{\mu\nu}$

Friedmann Equation
$(8\pi G/3)\rho = H^2 + K$

Concordance cosmology
$\rho_{cosmos} = 0.05\rho_{visible} + 0.25\rho_{dark\ matter} + 0.70\rho_{dark\ energy}$
-or-
$\rho = 0.05\rho_{crit} + 0.25\rho_{crit} + 0.70\rho_{crit} = \rho_{crit}$

Stress-energy tensor with Dark Energy
$T_{\mu\nu}$ = energy density + 3×(pressure)

Matter & energy densities decrease with size scale
$\rho_{matter} = \rho/R^3$ (applies to visible/dark matter)
$\rho_{energy} = \rho/R^4$ (applies to non-dark energy)
ρ_{energy} = constant (applies to dark energy)

Black hole parameters
($M_\odot$ = 1 solar mass)

Schwarzschild radius
$R_s = 2.96\times(M/M_\odot)$ km

Effective temperature
$T_{BH} = 6\times10^{-8} / (M/M_\odot)$ K

Power output
$P_{BH} = 9\times10^{-29} / (M/M_\odot)^2$ W

Evaporation time
$t_{BH} = 2.1\times10^{67} \times(M/M_\odot)^3$ years

Tidal forces
$\Delta g = 2GMh/r^3$