Problem 1

1) The optimum filter has a weighting function equal to the shape of the signal and it is replicated to collect all the possible pulses in each burst. Since the amount of pulses in a burst is variable, the filter must be designed to collect only three pulses (always present) per burst. Therefore, N_P= 3 * 600s/1s = 1800. SNR_{OPT}= V_P/sqrt(S_v/2) * sqrt(8T_P/3) * sqrt(1800). $V_{P,MIN}$=322.7nV.
2) A gated integrator on each pulse can be exploited; multiple pulses must be collected without resetting the capacitor. The optimum width of the integration window is T_G=3.1T_P. SNR_{GI}= V_P/sqrt(S_v) * sqrt(T_P) * 2.05* sqrt(1800). $V_{P,MIN}$= 363.6nV.
3) A zero setting can be exploited to limit the 1/f noise contribution. Since the time interval between pulses in a burst is too low to avoid noise doubling, a zero setting is performed before each burst. Since the second and the third pulse of the burst are distant from the zero setting anyway, it is convenient to use a large integration window for noise, e.g. $T_{G,N}$=30T_P. The 1/f noise in a burst can be roughly approximated as $\sigma_{1/f,B}$=sqrt($S_V f_C$(3.55+3.84+4.07))=1.07µV, while white noise is $\sigma_{W,B}$ =sqrt(3S_V*1/(2T_G))=22 µV. White noise is dominant on three pulses. However, this contribution can be reduced by using 600samples, while 1/f noise contribution remains the same (at first approximation). $\sigma_{W,B}$/sqrt(600)=0.9 µV, σ_{TOT}=1.4 µV. $V_{P,MIN}$= 1.71 µV.

Problem 2

1) Wheatstone bridge with one strain gauge and three resistors. Parameters of the strain gauge: R_0=100Ω, G=2, α=4*10^{-3} /K. The noise of resistors is negligible with respect to the preamplifier one. Due to power limitation $V_{BIAS,MAX}$=20mV. As a result, V_{OUT}= V_{BIAS}/4 * G * ε. Effect of temperature variation: 0.05 degrees correspond to 100 microstrain. Therefore, a temperature compensation scheme is needed to achieve the target sensitivity.
2) Assuming that the peaks of the signal can be acquired, the signal is sampled at its positive and negative peaks, with a time distance of 0.1s. By subtracting the two samples, signal is doubled, white noise is doubled, while a high pass filtering action on 1/f noise is provided. ε_{MIN}=996 microstrain, too high. The highest contribution is the white noise that could be reduced by acquiring more samples (tradeoff with speed) and/or with a low pass filter. None of these actions would be effective on 1/f noise contribution, whose value is too high to achieve the target sensitivity.
3) A modulation/demodulation scheme can be exploited to filter out the 1/f noise contribution. With a +/- Vbias power supply and a LIA with the same reference and LPF @50Hz to preserve the signal, ε_{MIN}=8.86 microstrain. This design fully meets the application requirements.