1. Amplifiers with feedback elements are commonly used in analog circuits.

(a, 50%) Consider the following small-signal π model of a BJT. By adding a resistor at the emitter of a common-emitter amplifier, it generates feedback effect and decreases the gain. Derive the transconductance gain \( (i_c/v_{in}) \) of this common-emitter amplifier with a resistor at the emitter, by assuming \( \beta \gg 1 \), where \( \beta = \frac{i_c}{i_b} \). (note: DC bias not shown in schematics)

(b, 50%) Consider the following small-signal π model of a MOSFET. By adding an inductor at source, it changes the input impedance. Derive the input impedance \( Z_{in} \). (note: DC bias not shown in schematics)
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2. Ring oscillators using inverters are commonly used in digital circuits to generate the reference clock. CMOS inverters, each has a delay of 1ns (one nano-second) as shown in the figure, are used in the following questions.

![Ring Oscillator Diagram]

(a, 50%) Design a ring oscillator, oscillating at 100MHz, by using the above inverters. Draw the circuit schematic. How many inverters do you need?

(b, 50%) The following circuit consists of two inverters. Can it function as a ring oscillator? If yes, what is the oscillation frequency? If not, explain the reason.