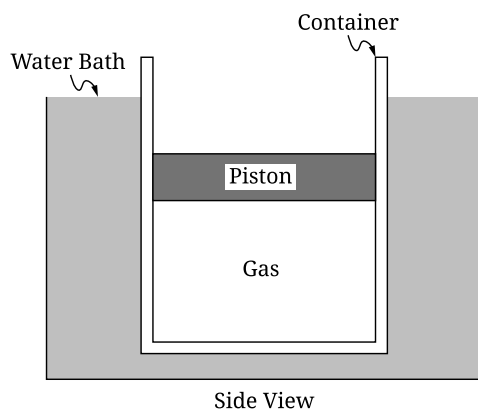


Question 2: Version J

2. A sample of a monatomic ideal gas is sealed in a thermally conducting container by a movable piston of mass M and area A . The container is in a large water bath that is held at a constant temperature T_0 . The piston is free to move with negligible friction. At the instant shown, the gas is in thermal equilibrium with the water bath, the piston is at rest, and the gas occupies volume V_0 . The pressure of the air above the piston is P_{atm} .



Note: Figure not drawn to scale.

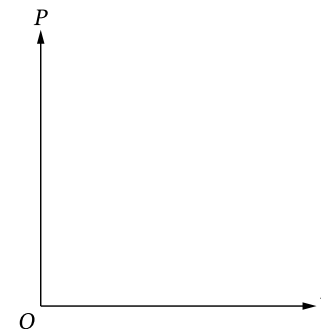
- A. On the dot shown, representing the piston, **draw** and **label** the forces that are exerted on the piston. Each force must be represented by a distinct arrow starting on, and pointing away from, the dot.



- B. **Derive** an expression for the internal energy of the gas in terms of M , A , V_0 , P_{atm} , and physical constants, as appropriate. Begin your derivation by writing a fundamental physics principle or an equation from the reference information.

- C. A block, also of mass M , is placed on the piston at time $t = t_0$ and is slowly lowered. The piston comes to rest at $t = t_f$ when the block is completely released.

On the axes provided, **sketch** the expected relationship between the pressure P and volume V of the gas for the thermodynamic process that the gas undergoes during time interval $t_0 \leq t \leq t_f$. **Draw** an arrow on your sketch to represent the direction of the thermodynamic process.



- D. With the block still on the piston, the temperature of the water bath is changed to a new constant temperature T_{new} . The gas occupies the original volume V_0 when the sample of gas and the water bath come to thermal equilibrium.

Indicate whether T_{new} is greater than, less than, or equal to T_0 .

_____ $T_{\text{new}} > T_0$

_____ $T_{\text{new}} < T_0$

_____ $T_{\text{new}} = T_0$

Briefly **justify** your answer by referencing at least one feature of your answers to parts A, B, or C.