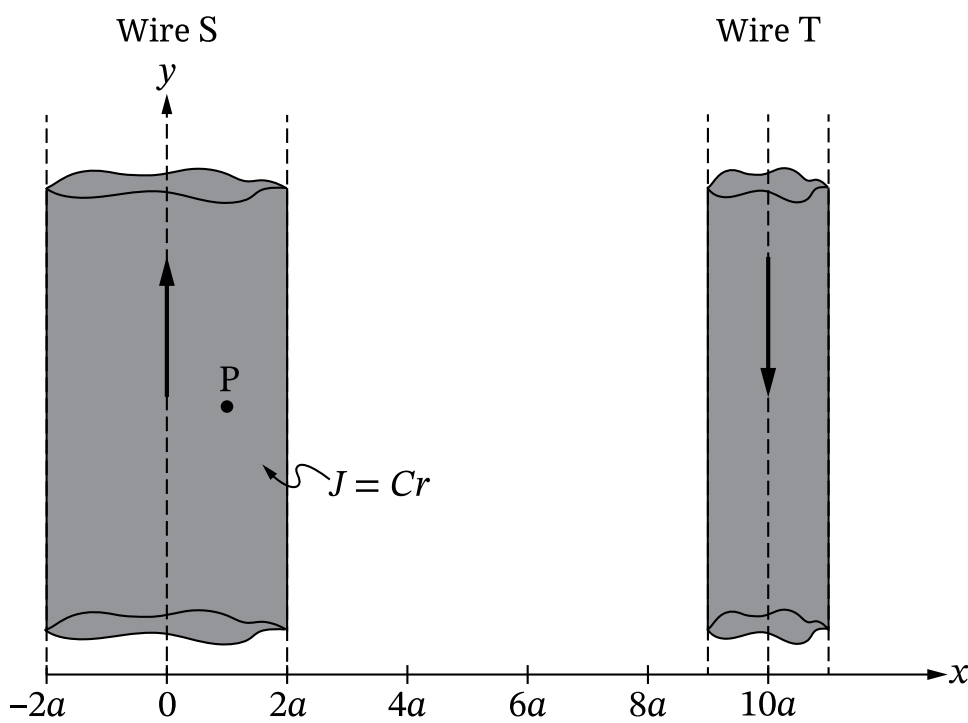


1. Two very long, cylindrical, current-carrying Wires S and T are oriented parallel to the y -axis, as shown in Figure 1. The centers of the wires are in the xy -plane. The wires are described as follows.
- Wire S has radius $2a$ and is centered at $x = 0$. Wire S has nonuniform current density and carries total current I_0 in the $+y$ -direction. The magnitude of the current density in Wire S as a function of the radial distance r from the center of the wire is described by $J = Cr$, where C is a positive constant.
 - Wire T has radius a and is centered at $x = 10a$. Wire T has uniform current density and carries total current I_0 in the $-y$ -direction.

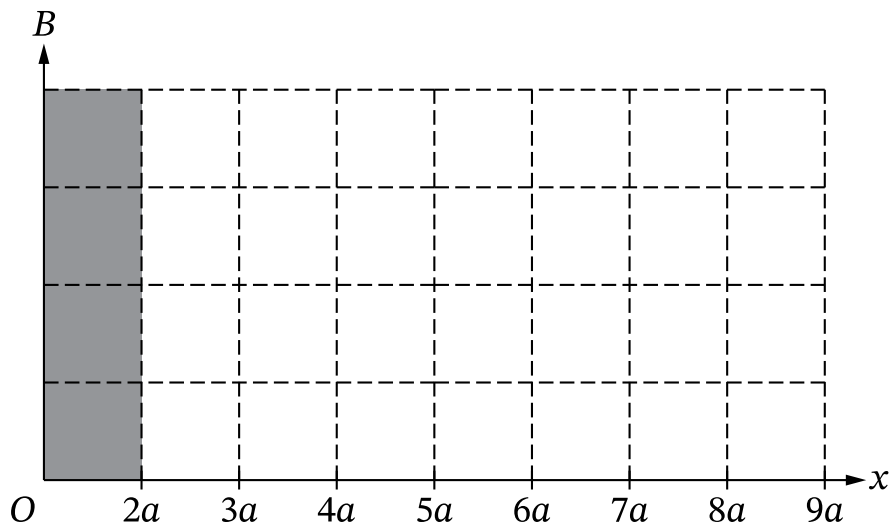
Figure 1



Part A

- Point P is located inside of Wire S at horizontal position $x = a$. **Derive** an expression for the magnitude of the magnetic field at Point P due only to the current in Wire S in terms of C , a , and physical constants, as appropriate. Begin your derivation by writing a fundamental physics principle or an equation from the reference information.
- On the axes shown in Figure 2, **sketch** a graph of the magnitude B of the magnetic field due to the currents in both wires as a function of x along the x -axis in the region $2a \leq x \leq 9a$. Sketches made in the shaded region will not be graded.

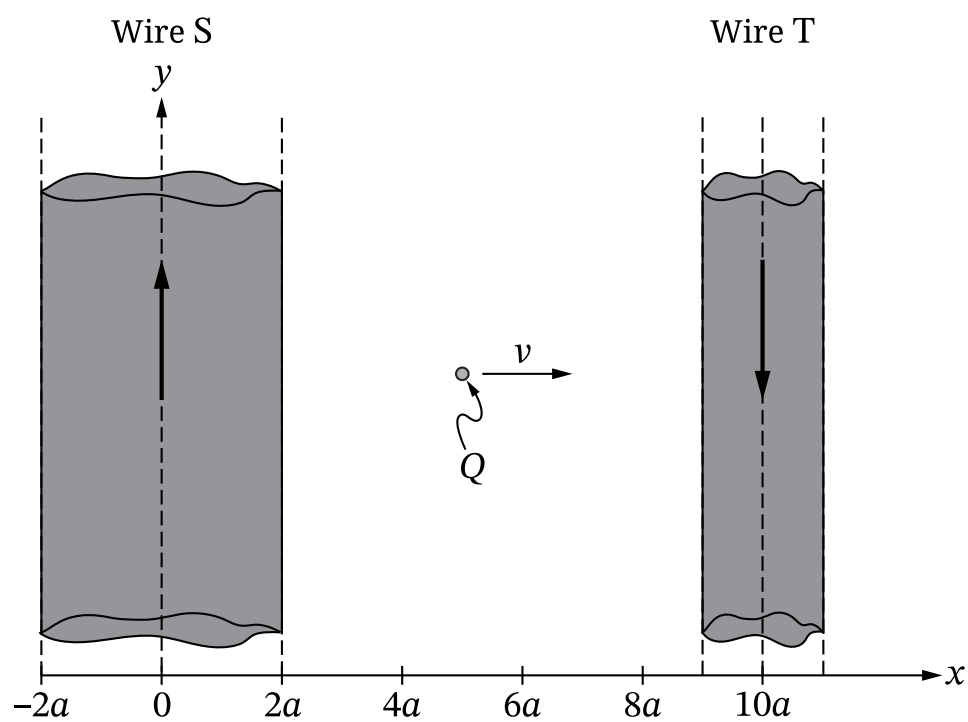
Figure 2



Part B

At the instant shown in Figure 3, a small sphere with charge Q is at horizontal position $x = 5a$ and moving in the xy -plane with speed v in the $+x$ -direction. At this instant, the net magnetic force exerted on the sphere due to the currents in Wires S and T has magnitude F .

Figure 3



Derive an expression for F in terms of a , Q , I_0 , v , and physical constants, as appropriate. Begin your derivation by writing a fundamental physics principle or an equation from the reference information.