

(i) Position of piston, x	
r	0.0762 m
ω	0.174533
t	1
$\cos \omega t$	0.9848
$\sin \omega t$	0.1736
	0.3048 m

r/l	0.25
$r/l \sin \omega t$	0.0434
x	0.3796 m

Variables	Values	Units
r	0.0762	m
l	0.3048	m
B	0.0508	m
θ	10 °	
P_g	6.90E+06	Pa

Calculated	
A_p	0.002027 m ²
F_g	1.40E+04 N

(ii) Gas Force, F_g	
P_g	6.895E+06 N/m ²
B	0.0508 m

Approximate Gas torque	
$T_{g(\text{approx})}$	230.611 Nm

Exact Gas torque	
Φ	0.0432212 rad
	2.4763908 deg
x	0.379555 m
	14.94311 inch
$T_{g(\text{exact})}$	2.30E+02 Nm

% Error (approx over exact)	
error	0.455%

gas force on the piston

$$F_g := \frac{\pi}{4} \cdot p_g \cdot B^2$$

approximate gas torque on the crank

$$T_{g21a} := F_g \cdot r \cdot \sin(\theta) \cdot \left(1 + \frac{r}{l} \cdot \cos(\theta) \right)$$

exact gas torque on the crank

$$\phi := \text{atan} \left[\frac{r \cdot \sin(\theta)}{l \cdot \sqrt{1 - \left(\frac{r}{l} \cdot \sin(\theta) \right)^2}} \right]$$

$$x := r \cdot \cos(\theta) + l \cdot \sqrt{1 - \left(\frac{r}{l} \cdot \sin(\theta) \right)^2}$$

$$T_{g21e} := F_g \cdot \tan(\phi) \cdot x$$

$$\text{error} := \frac{T_{g21a} - T_{g21e}}{T_{g21e}}$$

