# fn x_mul_2k

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This proof resides in **"contrib"** because it has not completed the vetting process.

Proves soundness of the implementation of `x_mul_2k` in `mod.rs` at commit f5bb719 (outdated[1]).

# 1 Hoare Triple

## Precondition

### Compiler-Verified

None

### User-Verified

$k \neq$ `i32.MIN`

## Pseudocode

```
1  def x_mul_2k(x: RBig, k: i32) -> RBig:
2      num, den = x.into_parts()   #
3      if k < 0:
4          den <<= cast(-k, usize)
5      else:
6          num <<= cast(k, usize)
7
8      return RBig.from_parts(num, den)
```

## Postcondition

**Theorem 1.1.** Return $x \cdot 2^k$.

*Proof.* Since $x$ is a fraction, line 2 splits $x$ into its numerator and denominator.
Consider two cases:

- If $k < 0$, then multiplying the denominator by $2^{-k}$ is equivalent to multiplying by $2^k$. Since $k$ is negative, then $-k$ is positive, meaning the cast to `usize` is valid. Shifting $-k$ zeros to the left is equivalent to multipying the denominator by $2^k$. Negation of $k$ is well-defined for all values of `i32`, except for `i32.MIN`, which is not allowed by the precondition. Therefore, the result is $x \cdot 2^k$.

- If $k \geq 0$, then we multiply the numerator by $2^k$. Since $k$ is positive, the cast to `usize` is valid. Shifting $k$ zeros to the left is equivalent to multipying the numerator by $2^k$. Therefore, the result is $x \cdot 2^k$.

In both cases, the result is $x \cdot 2^k$. □

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[1]See new changes with `git diff f5bb719..0684fea rust/src/measurements/noise/nature/float/utilities/mod.rs`