QUESTION

Draw the expiry payoff diagrams for each of the following portfolios (ignore premium costs):

(a) Short one share, long two calls with exercise price K (this one is called a straddle);

(b) Long one call and one put, both with exercise price K (this is also a straddle);

(c) Long one call, and two puts, all with exercise price K (a strap);

(d) Long one put and two calls, all with exercise price K (a strip);

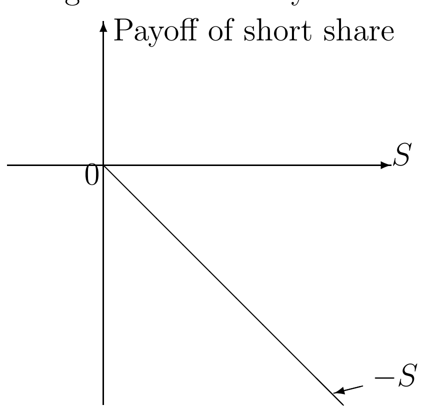
(e) Long one call with exercise price K_1 and one put with exercise price K_2; compare the three cases $K_1 > k_2$ (also a strangle), $k_1 = k_2$ and $k_1 < k_2$;

(f) As in (e), but also short one call and one put with exercise price K, where now $k_1 < K < k_2$ (a butterfly spread).

ANSWER

In what follows payoff is drawn for the owner of the portfolio and ignores premium.

(a) "Short" means you have a liability to but a share rather than being "long" which means you own it. Thus the payoff from a short share is

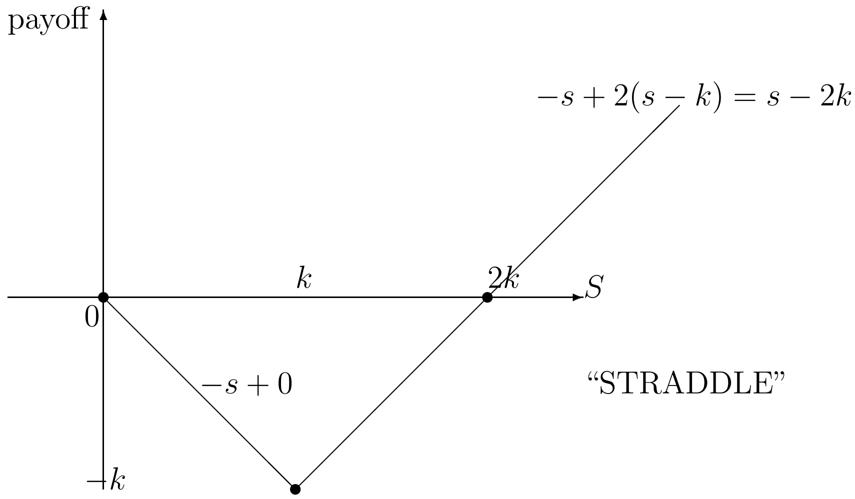


Payoff of a call to the owner is $= \max(s-k,0)$

Thus payoff of 2 calls is $= 2\times\max(s-k,0)$

Thus the total payoff of portfolio is $= -s + 2\max s - k, 0$

Graphically

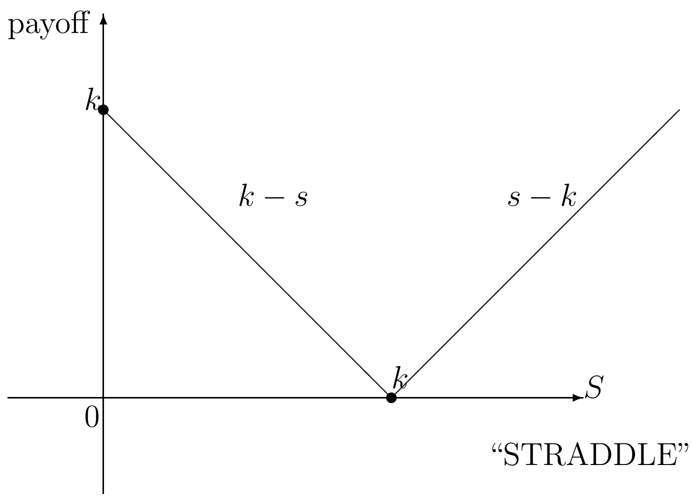


"STRADDLE"

(b) Long call payoff$=\max(s-k,0)$

Long put payoff$=\max(k-s,o)$

Total payoff$=\max(s-k,0)+\max(k-s,0)=\begin{cases} k-s, & k\geq s \\ s-k, & k\leq s\end{cases}$ Similar shape to other "straddle" hence name.

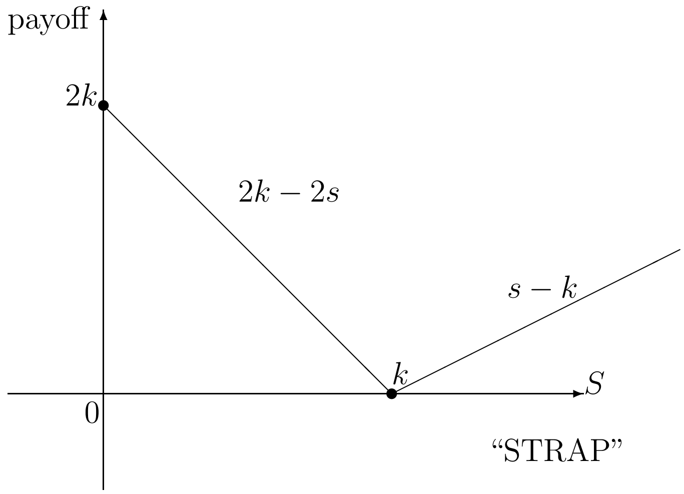


"STRADDLE"

(c) Long one call $=\max(s-k,0)$

Long two puts$=2\max(k-s,0)$

Total payoff$=\max(s-k,0)+2\max(k-s,0)=\begin{cases} s-k, & s\geq k \\ 2(k-s), & s\leq k\end{cases}$

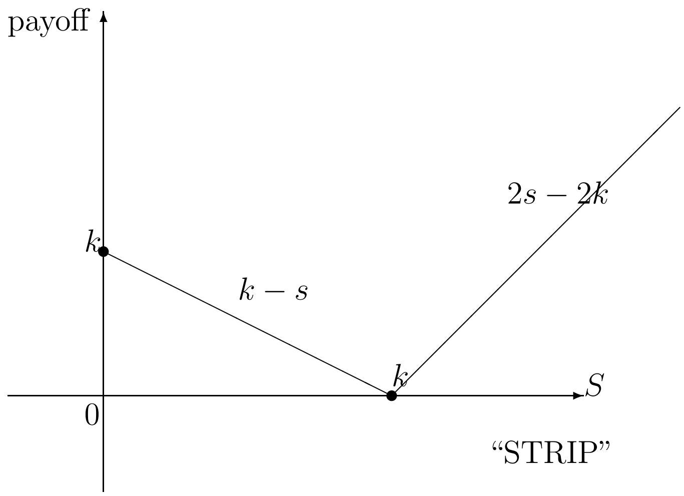


"STRAP"

(d) Long one put$= \max(k-s,0)$

Long two calls$= 2\max(s-k,0)$

Total payoff$= \max(k-s,0)+2\max(s-k,0) = \begin{cases} 2(s-k), & s \geq k \\ k-s, & s \leq k \end{cases}$

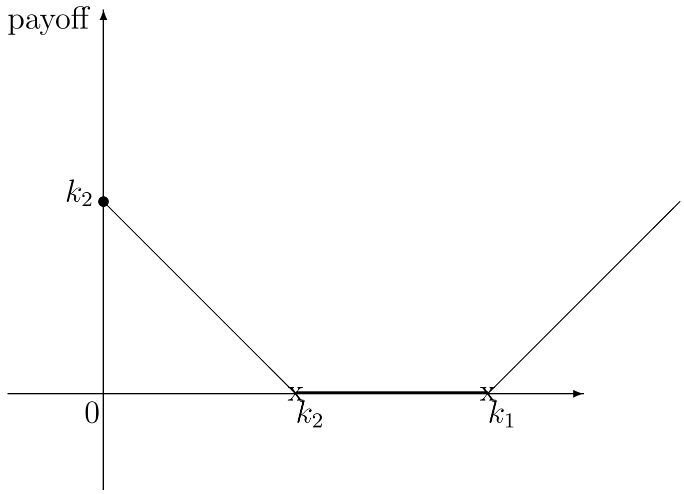


"STRIP"

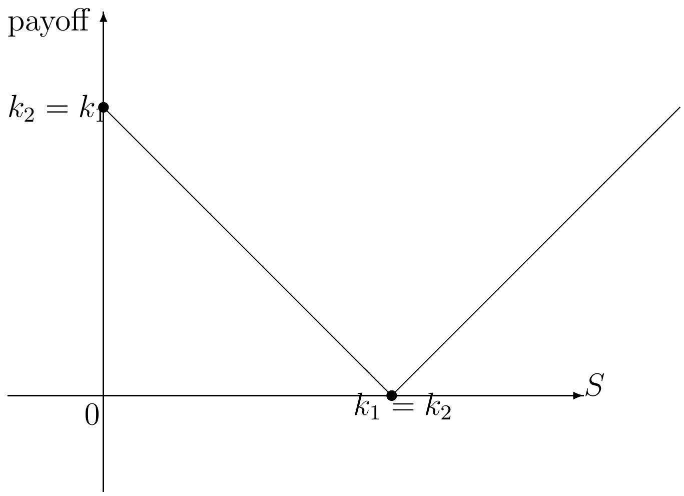
(e) Long one call, strike $k_1 = \max(s-k_1,0)$

Long one put, strike $k_2 = \max(k_2-s,0)$

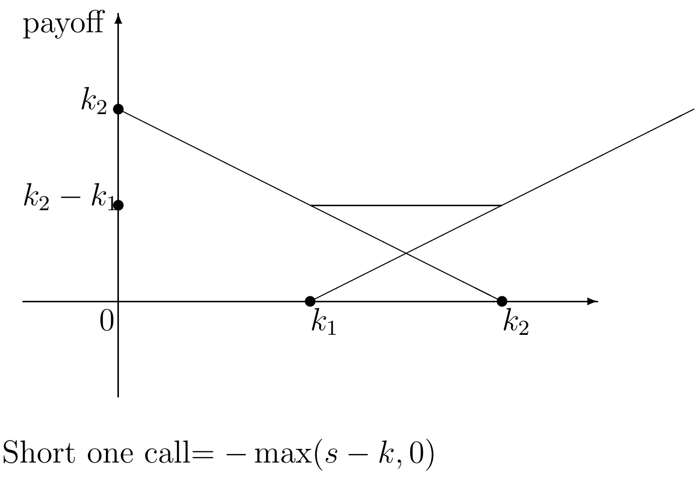
$\underline{k_1 > k_2}$



$\underline{k_1 = k_2}$



$\underline{k_1 < k_2}$



(f) Short one call$= -\max(s-k, 0)$

Short one put$= -\max(k-s,0),\ k_1 < k < k_2$

Long one call$= \max(s-k,0)$

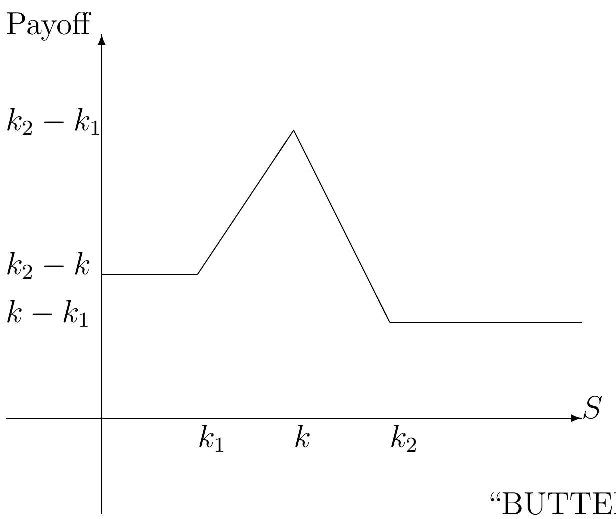
Long one put$= \max(k_2-s,0)$

Total payoff$= \max(k_2-s,0)+\max(s-k_1,0)-\max(k-s,0)-\max(s-k,0)$

Split into several ranges

$$
\begin{array}{rcl}
0 < s < k_1 (< k < k_2) \Rightarrow & -(k-s)+k_2-s & = k_2-k \\
0 < k_1 < s < k < k_2 \Rightarrow & -(k-s)+s-k_1+k_2-s & = k_2-k-k_1+s \\
0 < k_1 < k < s < k_2 \Rightarrow & -(s-k)+s-k_1+k_2-s & = k_2+k-k_1-s \\
0 < k_1 < k < k_2 < s \Rightarrow & -(s-k)+s-k_1 & = k-k_1
\end{array}
$$

Graphically:



"BUTTERFLY SPREAD"