For PSpice computation use 1N5231 Zener diode
(Manufacturer’s specifications at 27°C are: \( V_Z = 5.1 \)
@ \( I_Z = 20\)mA, \( r_Z = 175\)Ω @ 1mA, \( r_Z = 8.2\)Ω @ 5mA, \( r_Z = 2.2\)Ω @ 20mA. ). For design estimates use an
idealized model with \( v_Z = 5.1 \) volts and \( r_Z \rightarrow 0 \). The
circuit shown is to be used to limit the load current to
the range indicated at a 5.1 volt (nominal) voltage.
The resistor R is required to have a 0.25 watt rating.
Select a standard value for R to meet the
specifications. What voltage should the supply be set
to?

Specify (say) 0.1\( I_Z = 2\)ma as the minimum (‘keep-alive’) Zener current. This value is selected as one
above which the changes in Zener resistance (or slope of the characteristic) appear to be acceptable for the
specification. The max Zener current is selected as \( I_Z = 20\)mA.

The supply current, assuming the Zener operates in the breakdown region, is \((V-5.1)/R \). When the load
draws maximum current then Zener diode draws its minimum current, and to operate in breakdown require
\((V-5.1)/R \geq 2\)ma + 20\( ma \) = 0.022
or
\( V \geq 5.1 + 0.022R \)
Similarly when the load draws minimum current the Zener must not draw more than the maximum current
specified, i.e.,
\((V-5.1)/R \leq 20\)ma + 24\( ma \) = 0.024
or
\( V \leq 5.1 + 0.024R \)

Note that these are inequalities, and values for \( V \) and \( R \) cannot be obtained analytically.

One more condition is specified; the resistor power handling requirement. The requirement is
\((V-5.1)^2/R \leq 0.25 \)
or
\( V \leq 5.1 + 0.5\sqrt{R} \)

These three curves were plotted (Cricket Graph) and the plot is shown below. The current conditions are
met at coordinate points between (and including) the lines. (Note: A broad range of points was plotted and
an interesting portion of the plot enlarged.) The power constraint further limits the acceptable parameter
area to the portion of the area between the lines which is also beneath the power curve.

And the constraint to use standard resistance values, say 5% tolerance devices, limits choices still more.
One might choose, for example, \( R = 470\)Ω and set \( V \) to (say) 16 volts. On the other hand 330Ω is an
option, although the pertinent portion of the plot is not shown for that resistance value.

Note that there is not a unique answer to the problem. Selecting an answer, however, is not a matter simply
of making an arbitrary choice. A good thought to keep in mind id that if there is a choice use it to provide
as much advantage as can be had. For example is there a choice which enables uses of a standard battery
voltage so that an adjustable or a special order supply is avoided. Check it out.
A plot of the output from a PSpice computation is shown below.

Zener Problem: $R = 470 \Omega, V = 16 \text{ volts}, 1N5231$