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NORMAL COLOUR VISION | PROTANOPIA SIMULATION

SPORTS SURFACING FOR THE COLOUR BLIND

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INTRODUCTION

Colour Blindness also known as Colour Vision Deficiency or more simply CVD affects more than 1 million Australians. CVD varies greatly from the almost normal to the hard to imagine world of those who see nothing but varying shades of grey. Many people with CVD can have great difficulty in almost all aspects of their lives including education, employment and participation in normal everyday activities, such as sport.

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Imagine playing football whilst being unable to differentiate between your team and the opposing team's uniforms. Imagine playing cricket when the ball appears to be the same colour as the grass. Imagine playing netball on a court when the line markings appear to be the same colour as the surface. Imagine playing hockey and not being able to see the puck flying at your head. The bright pink cricket ball popular in Australia for night games is easy to see to the normal human eye under flood lights, however, to some with CVD that same ball can be almost invisible. These are just some of the problems faced every day by those with CVD. This is an educational guide aimed at highlighting those difficulties and providing information on how to reduce them.

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UNDERSTANDING COLOUR BLINDNESS

Colour Blindness is one of the world's most common inherited, genetic disorders. Males are more likely to be colour blind than females as the genes responsible for the most common forms of colour blindness are on the X chromosome. Females have two X chromosomes so a defect in one is typically compensated for by the other, while males only have one X chromosome. As a result, about 8% of males and 0.5% of females are colour blind.

We see colour through three types of specialised nerve cells called cones. These cones absorb red, blue and green light enabling us to see the full spectrum of colours. In those with CVD, one or more of those cones are faulty or don't function at all. The three types of CVD are **Anomalous Trichromacy,** Dichromacy and Monochromacy.

ANOMALOUS TRICHROMACY

In people with **Anomalous Trichromacy** all of their three cone types are used to perceive colour, but one type of cone perceives colour slightly out of alignment.

The different Anomalous Trichromacy conditions are:

Protanomaly is a reduced sensitivity to red
Deuteranomaly is a reduced sensitivity to green
Tritanomaly is a reduced sensitivity to blue

DICHROMACY

In people with **Dichromacy** only two of their three cone types are used to perceive colour, so they have a total absence of function of one cone type.

The different Dichromatic conditions are:

Protanopia is being unable to perceive any red
Deuteranopia is being unable to perceive any green
Tritanopia is being unable to perceive any blue

MONOCHROMACY

People with Monochromacy can see no colour at all, their world consists of different shades of grey ranging from black to white. It is extremely rare, occurring only in approximately 1 in every 33,000 people and its symptoms can make life very difficult.

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COMMON FORMS OF COLOUR BLINDNESS

Protan and Deutan Deficiencies: Protan and Deutan deficiencies are very common, have many similarities and can vary from mild to severe forms. These conditions are commonly known as red/green colour blindness. Someone with Protanopia will not just be unable to see the colour red, they will also have difficulty discerning the colour purple as they can't see the red element in the purple. This applies to all colours with a red element. The next two pages contain a series of photos, the photos shown on the left depict normal colour vision while the photos on the right depict how the same image may appear to someone with the different types of Dichromatic vision. The images are simulations of dichromatic vision only and are therefore not accurate examples of how everyone with a colour vision deficiency might see.

PROTANOPIA

Note the AFL field and running track colours are almost the same in the Protanopia simulation.

Protanopes are more likely to confuse:

1. Black with many shades of red
2. Dark brown with dark green, dark orange and dark red
3. Some blues with some reds, purples and dark pinks
4. Mid-greens with some oranges
5. Yellows with bright greens

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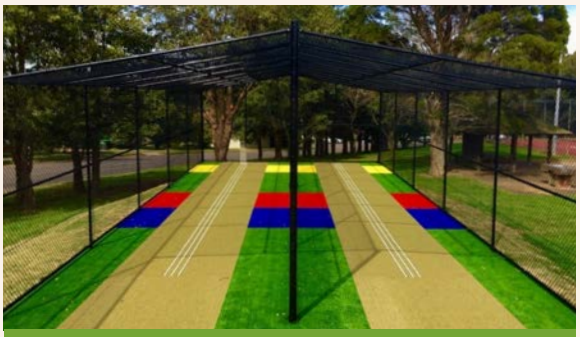
PROTANOPIA SIMULATION

DEUTERANOPIA

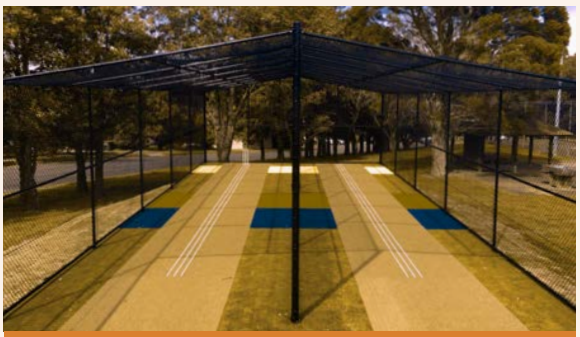
Note the red training squares disappear entirely in the Deuteranopia simulation.

Deuteranopes are more likely to confuse:

1. Mid-reds with mid-greens
2. Blue-greens with grey and mid-pinks
3. Bright greens with yellows
4. Pale pinks with light grey
5. Mid-reds with mid-brown
6. Light blues with lilac



NORMAL COLOUR VISION



DEUTERANOPIA SIMULATION

RARE FORMS OF COLOUR BLINDNESS

Tritanopia and Monochromacy: Unlike red-green color blindness Tritanopia and Tritanomaly are very rare. They are not sex-linked traits and therefore women and men are equally affected. Someone with Tritanopia will not just be unable to see the colour blue, they will also have difficulty discerning the colour green as they can't see the blue element in the green. This applies to all colours with a blue element. It is important to be aware that different light conditions will change how different colours are perceived. For example, even someone with a very mild colour vision deficiency may have difficulty seeing the different colours shown in the below images depending on whether or not they are outside on a sunny day or a rainy/cloudy day or they are inside or outside under floodlighting. These varied light conditions affect how colour is perceived by those with and without CVD.

TRITANOPIA

Note the contrasting yellow and white lines in the original photo appear to be the same colour in the Tritanopia simulation.

Tritanopes are more likely to confuse:

1. Light blues with greys
2. Dark purples with black
3. Mid greens with blues
4. Oranges with reds

NORMAL COLOUR VISION

TRITANOPIA SIMULATION

MONOCHROMACY

People with Monochromatic vision can see no colour at all. Imagine, if you can, your entire world looking like an old black and white movie. This is the only world those with Monochromatic vision know.

NORMAL COLOUR VISION

MONOCHROMATIC SIMULATION

WHY DESIGN FOR THE COLOUR BLIND

Colour Blindness is often not considered a serious impairment and is overlooked when it comes to sports facility design. How many men, women and children in Australia are currently being excluded from sport because schools, clubs and venues are unaware of the difficulties faced by them?

4.5% of all participants and spectators are colour blind, bear in mind that in male only teams and/or events, that number increases to 8%, that's...

1 in every 12 men

Considering the colour blind when designing facilities is not difficult. The impact on players and spectators by not doing so could be far greater than a lot of us are comfortable with. Participants with CVD often do not perform as well and could turn away from sporting activities altogether because of it. The exclusion of anyone from any physically and socially healthy activity is a serious issue, even more so when considering the large number of Australians and people worldwide with CVD. If a participant is having difficulty discerning the ball, perimeter lines or flags and signage, this could easily lead to accident and injury, in that case, doesn't CVD then become a community issue?

Spectators, whether watching live or on TV will lose enjoyment and may discontinue watching if he or she has troubling following games due to CVD. This applies to all levels of sport from local, children's games to elite, international events around the world.

Venues often use colour coding for everything from seat locations, toilet locations and car parking information to advertising, venue maps and exit and emergency signs. Players and spectators with CVD can have difficulty navigating a venue and following a game which diminishes their overall experience. More importantly, safety can be a serious issue in emergencies for those with CVD if they are unable to clearly discern colour coded exit and emergency signage, because the signs appear to be the same colour as the background surface and don't stand out in an emergency situation.

Many factors come into play when designing sporting facilities and it's unrealistic to assume it would be possible to address CVD in every case. However, if we're aware of the difficulties faced by those with CVD, we can then consciously consider them when designing facilities and make positive choices in an attempt to minimise the difficulties they face. Contributing to the inclusion of anyone in sport is always worth considering.

DESIGNING FOR THE COLOUR BLIND

For many years, green was the only surface colour available in synthetic grass. Today, manufacturers are offering more and more colour choices and vibrant colour combinations have become the norm for sports surfacing.

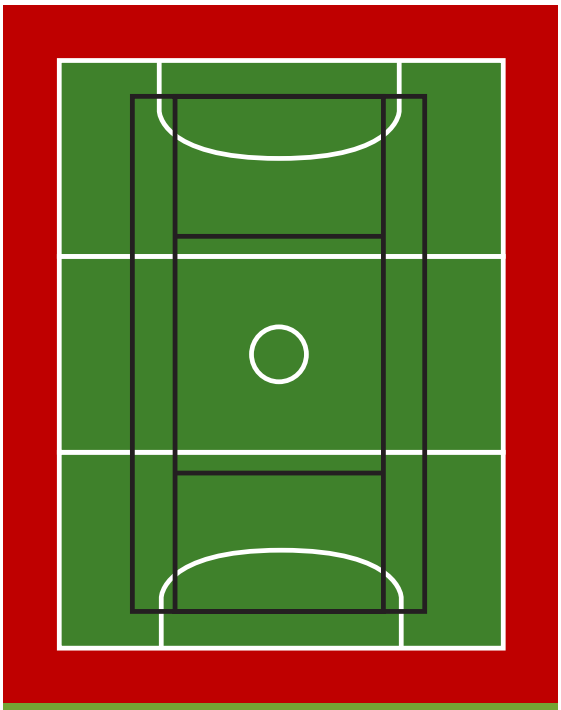
Colour is not just important for aesthetic reasons but also for branding. Schools, clubs, councils, sponsors and venues will often choose a colour combination that reflects and maintains their brand. Therefore, the idea of restricting colour choices is less than appealing for all. However, with a little consideration, it's not difficult to design a colour blind friendly surface whilst still maintaining branding, whatever your desired colour combination may be.

As only line marking determines an area of play, there are no "bad" surface colour choices or combinations. Once a surface colour or colours have been chosen, it's simply a matter of choosing the right contrasting colours for the line markings.

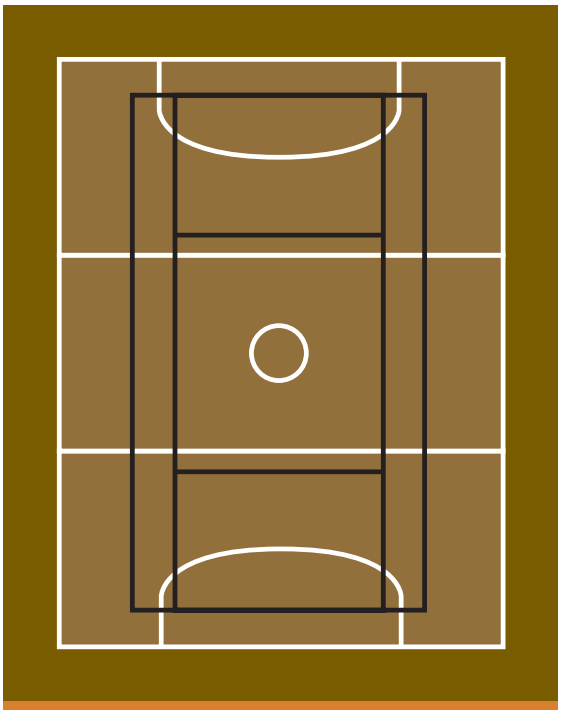
Green and red are the most problematic colours for the largest number of people with a colour vision deficiency and the two colours together usually clash, however, even this offending combination is not off limits when designing a colour blind friendly sports surface.

For example, if red and green are the desired surface colour combination on a court with two line markings, a workable combination would be a green playing area and a red run off area with black and white line marking. As red and black often "clash", ideally the black lines would be placed on the green playing area leaving the white lines bordering the red run off area. The court is now 'colour blind friendly" even with the clashing red and green colour combination.

The clashing red and green surface colours will still be difficult to discern for many with CVD, however, this will not affect their ability to discern the areas of play, as only line marking determines an area of play. All surface colour combinations are possible, as long as the right contrasting line marking colours are chosen. This is the key to designing colour blind friendly surfaces with little or no impact to aesthetics or branding.



NORMAL COLOUR VISION



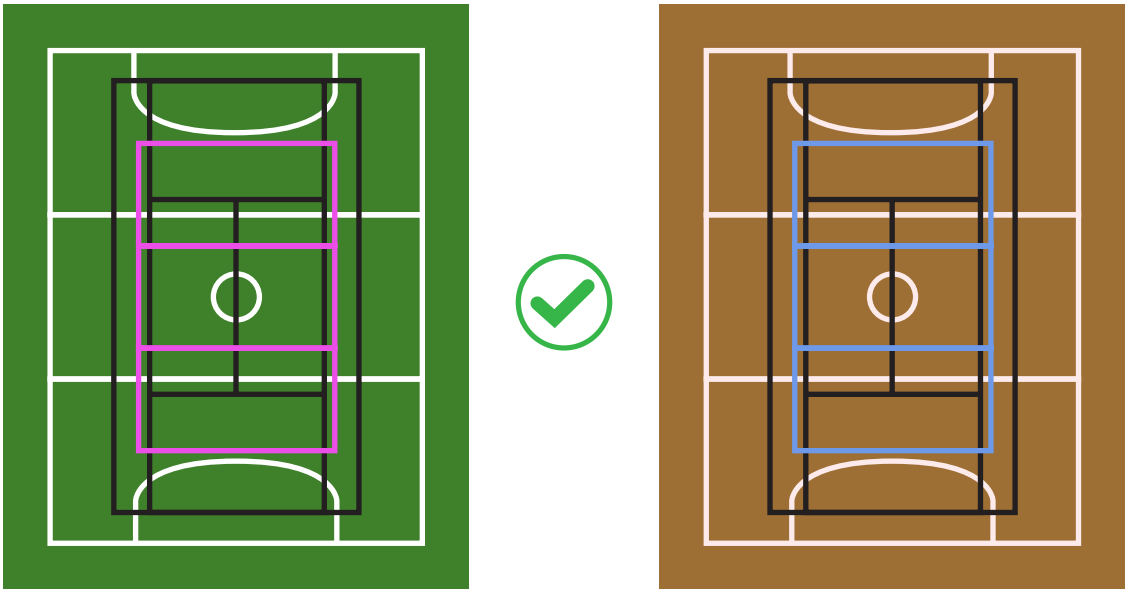
DEUTERANOPIA SIMULATION

LINE MARKING A GREEN SURFACE

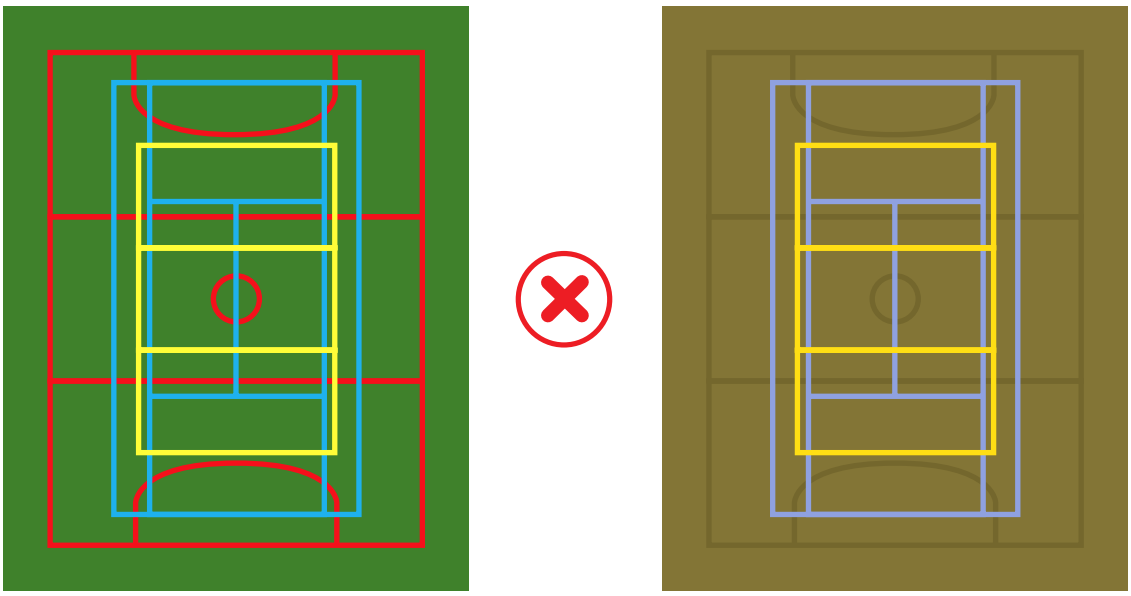
If line marking a green surface, try to avoid:

- Dark brown
- Oranges
- Reds
- Yellows
- Blues

The line marking colour combination in the top image on the left is clearly discernible In the Protanopia simulation in the top image on the right. The line marking colour combination in the bottom image on the left is problematic as the red line marking almost disappears against the green surface in the Protanopia simulation in the bottom image on the right.



NORMAL COLOUR VISION | PROTANOPIA SIMULATION



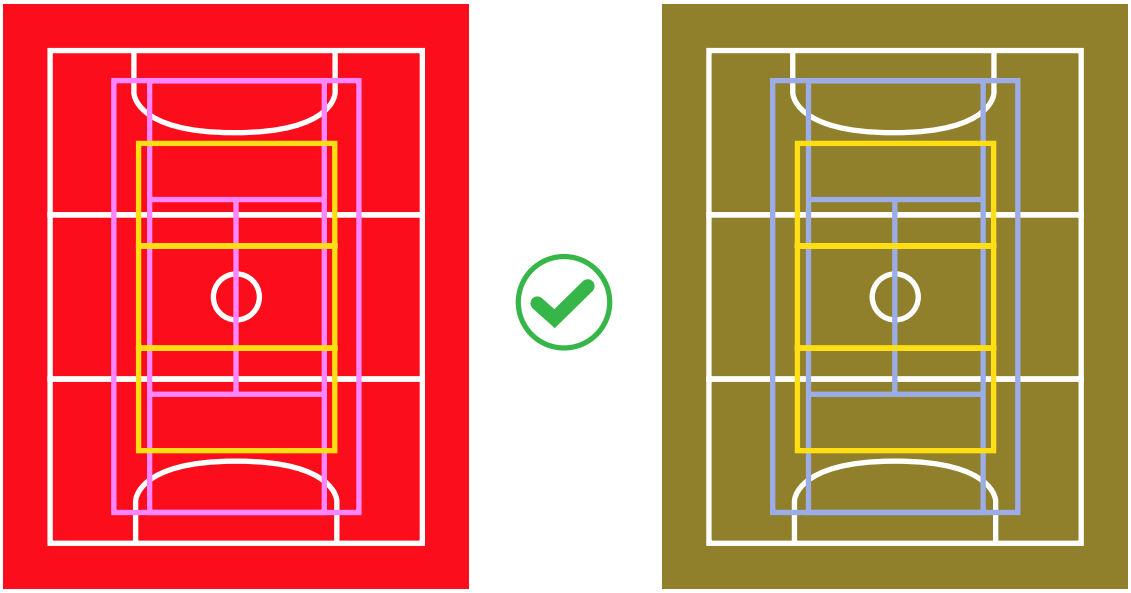
NORMAL COLOUR VISION | PROTANOPIA SIMULATION

LINE MARKING A RED SURFACE

If line marking a red surface, try to avoid:

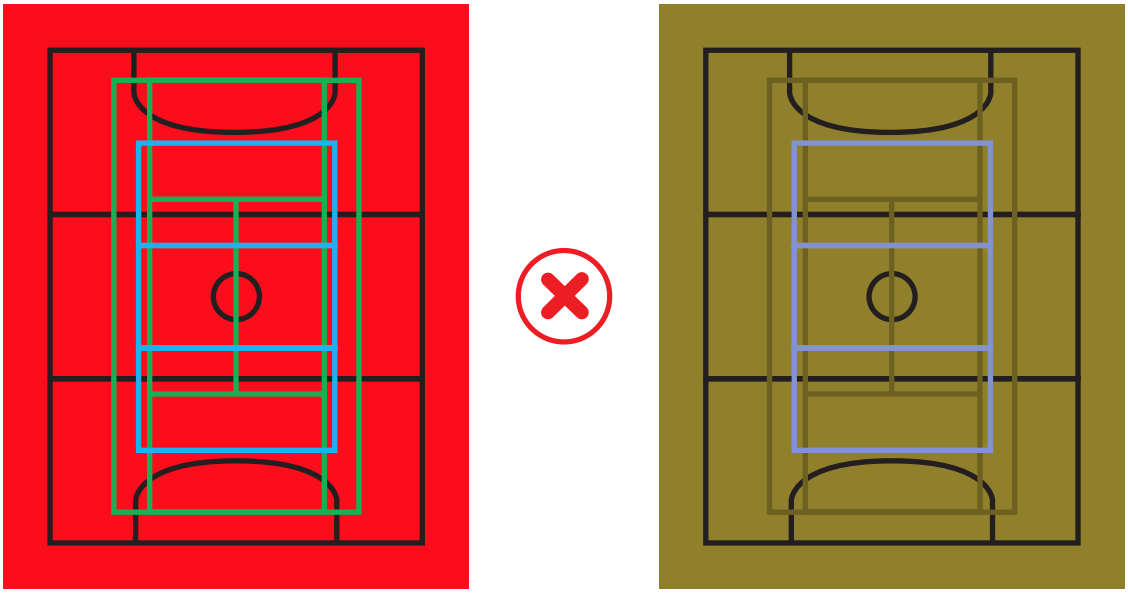
- Blacks
- Blues
- Greens
- Dark browns
- Mid browns
- Oranges

The line marking colour combination in the top image on the left is clearly discernible In the Protanopia simulation in the top image on the right. The line marking colour combination in the bottom image on the left is problematic as the green line marking almost disappears against the red surface in the Protanopia simulation in the bottom image on the right.



NORMAL COLOUR VISION

PROTANOPIA SIMULATION



NORMAL COLOUR VISION

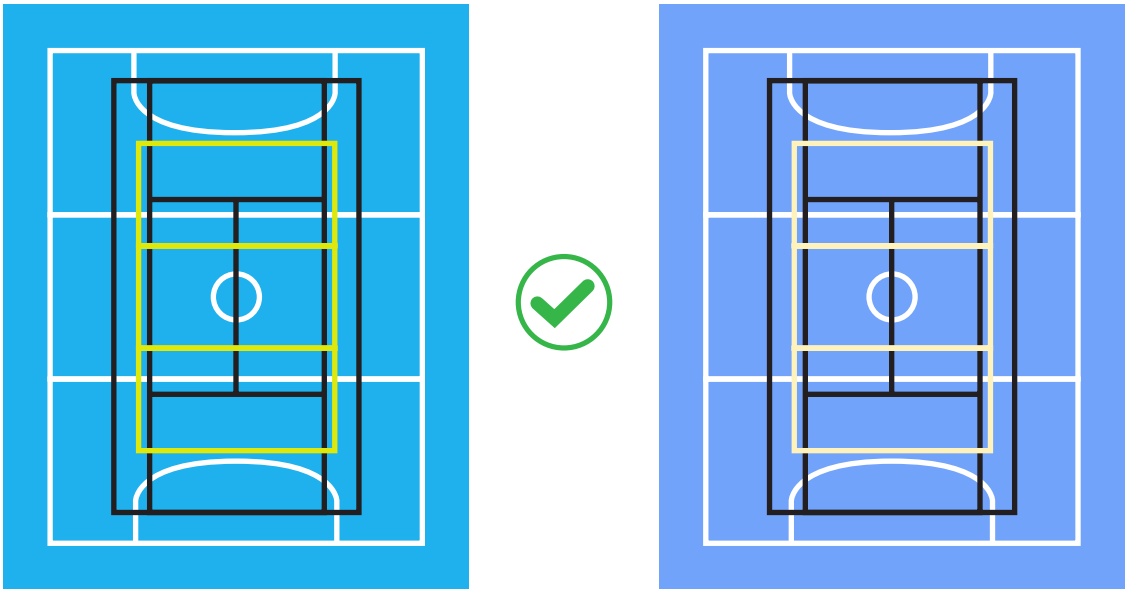
PROTANOPIA SIMULATION

LINE MARKING A BLUE SURFACE

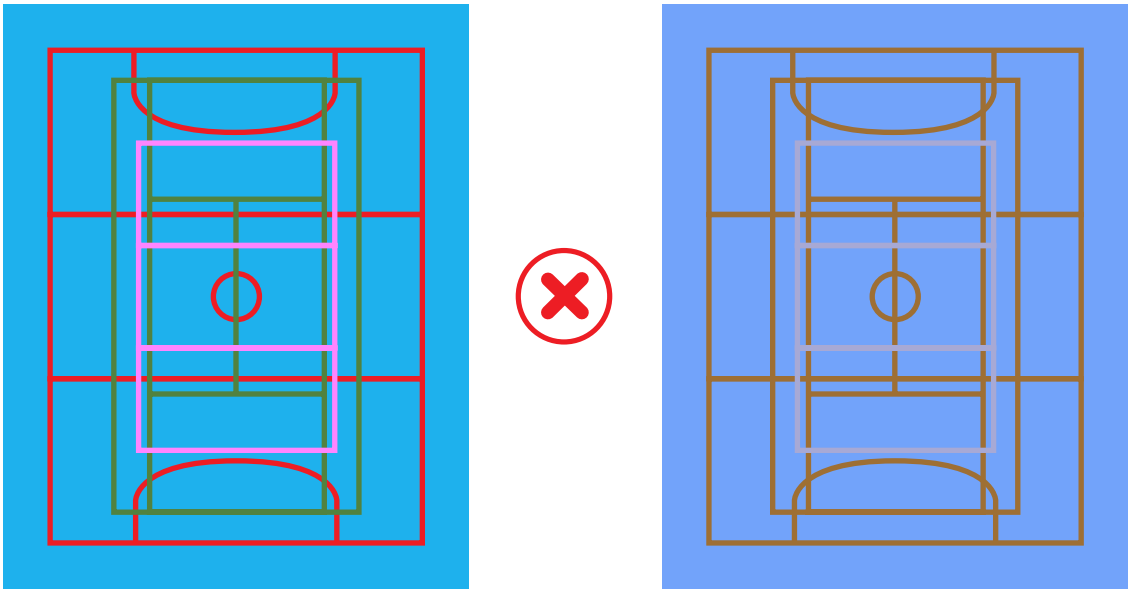
If line marking a blue surface, try to avoid:

- Reds
- Purples
- Pinks
- Lilacs
- Greys
- Greens

The line marking colour combination in the top image on the left is clearly discernible in the Deuteranopia simulation in the top image on the right. The line marking colour combination in the bottom image on the left is problematic as the line marking colours are difficult to distinguish between in the Deuteranopia simulation in the bottom image on the right.



NORMAL COLOUR VISION | DEUTERANOPIA SIMULATION



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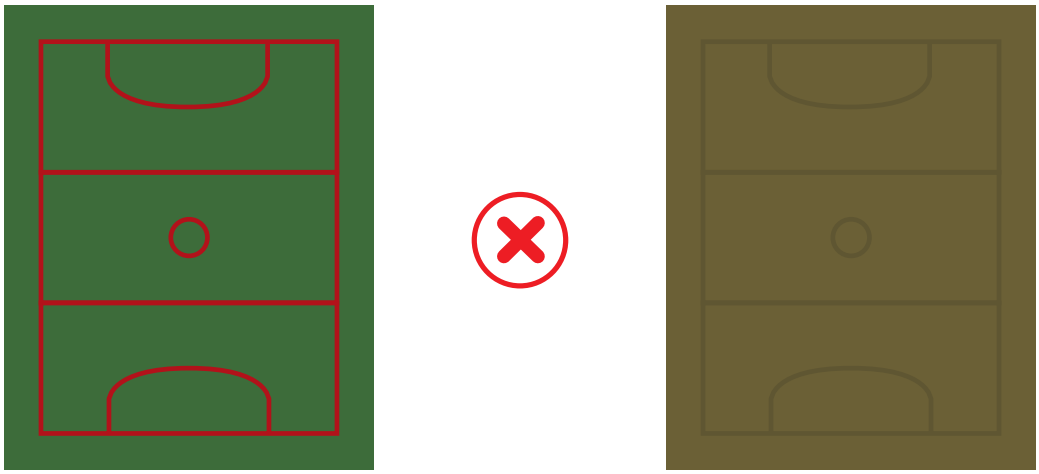
LIGHT VS DARK

The approximate light reflectance value of a colour indicates the amount of visible light that a colour will reflect. Black has a light reflectance value of 0% and absorbs all light. In contrast, white has a light reflectance value of 100%. All colours fit within these two extremes.

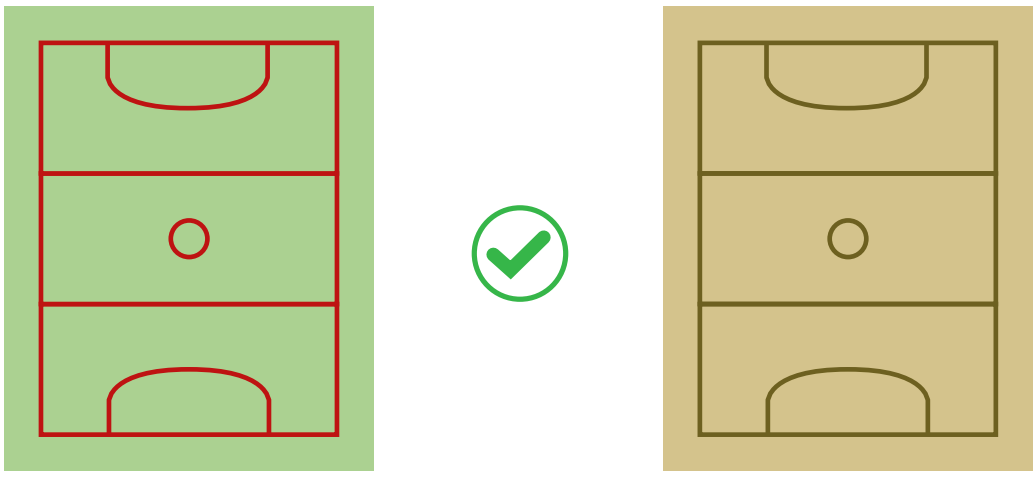
For best practice, aim to ensure a minimum colour contrast ratio of 3:1 between adjacent colours at the digital design stage, in order to achieve the minimum recommended Light Reflectance Value differential of 30 between adjacent colours on the physical playing surface.

Even those with CVD can tell the difference between a very light colour and a very dark colour, so another option when using clashing colours together, such as red and green, is to use a really light green and a very dark red. Most people with CVD will at least be able to distinguish the red from the green based on light vs. dark. Knowing this may allow you to choose a different shade of the same colour, rather than having to eliminate one clashing colour altogether.

You can see in the top images that the red line marking on the green surface is very difficult to see in the Protanopia simulation, whereas in the bottom images, the dark red line marking on the light green surface is easily distinguished in the Protanopia simulation.



NORMAL COLOUR VISION | PROTANOPIA SIMULATION



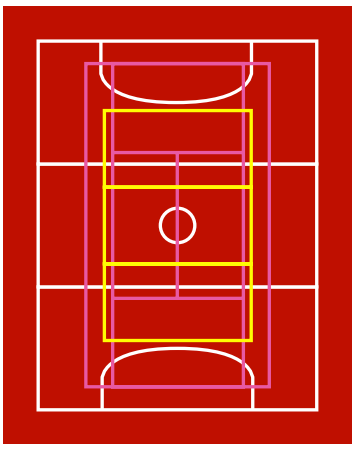
NORMAL COLOUR VISION | PROTANOPIA SIMULATION

LINE MARKING PLACEMENT

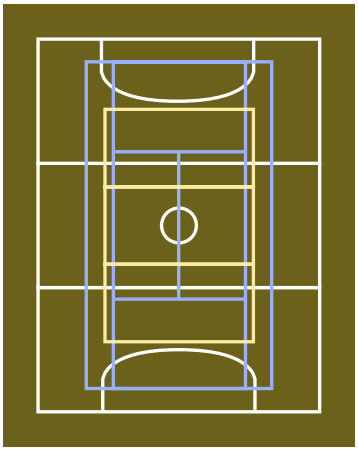
As more and more vibrant colours in varying shades are introduced, we have more and more different colour combinations to choose from. Designing a colour blind friendly surface with four or more line markings can be difficult, so the availability of a greater range of colours and shades increases our chances of finding a workable combination.

When using similar shades of different coloured lines on the same surface, such as white and yellow for example, be mindful that the two colours could look very similar to some with CVD. If needing to utilise two clashing line marking colours or two line marking colours of similar shade, one option is to consider the line marking placement on the surface. Keep the clashing lines as far apart as possible, there will always be some crossover, the idea is to minimise it as much as you can. The top images show white lines on the larger, outer court area and yellow lines on the smaller inner court area. As you can see by the Protanopia simulation, the two colours appear to be very similar. By keeping the two line markings separated as much as possible, we minimise crossover and reduce the chances of confusion for those with CVD.

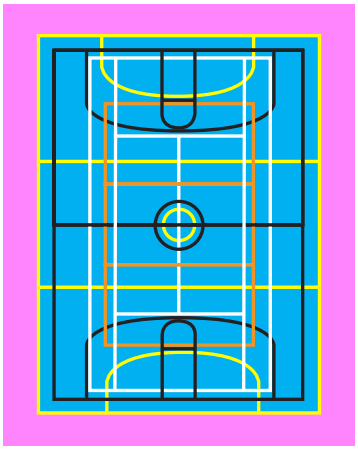
The bottom image on the left shows yellow, orange, black and white line marking on a light blue surface. The yellow and orange colour combination is not always ideal but the placement of the yellow lines on the outer court area and the orange lines on the smaller, inner court area, again minimises crossover and reduces the chances of confusion.



NORMAL COLOUR VISION



PROTANOPIA SIMULATION



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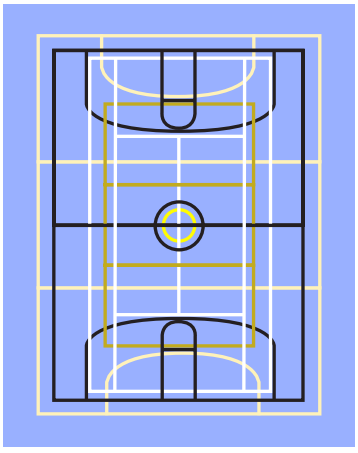
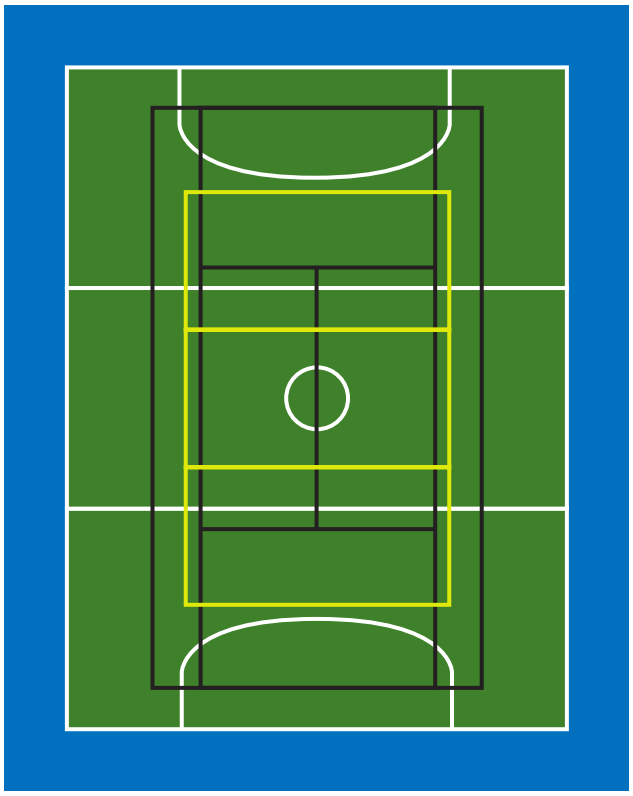


PROTANOPIA SIMULATION

INTERCHANGING PLAYING & RUN OFF AREAS

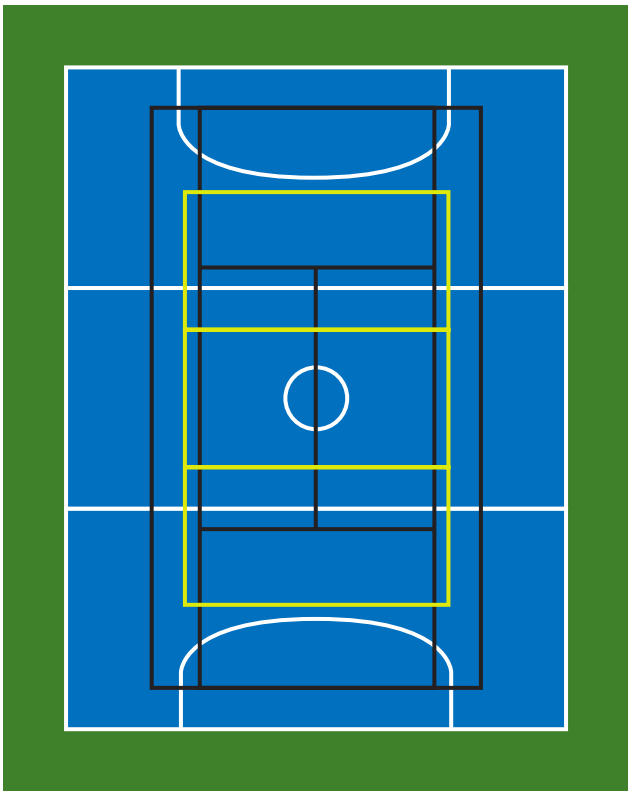
Interchanging playing area colours with run off area colours can have a big impact on surface colour combinations as it allows more flexibility when choosing line marking colours. This is particularly important when it comes to branding. If you have a logo of red and blue, choosing a blue playing area and red run off area would be a better option than the other way around. As red clashes with a lot more colours than blue does, choosing the blue playing area will give you a greater choice of line marking colours.

For example, take a school with a logo of green, blue and yellow who have always surfaced their courts and fields utilising a green playing area and blue run off area with black, white and yellow line marking. This is a less than ideal combination as green and yellow together can be difficult to discern for many people with CVD. To make a colour blind friendly court, there is no need to remove any of the logo colours, simply exchange the playing area and run off area colours and you've eliminated the problematic green/yellow combination, whilst maintaining the brand.



BEFORE

The yellow line marking on the green surface could be difficult to discern for many with CVD.



AFTER

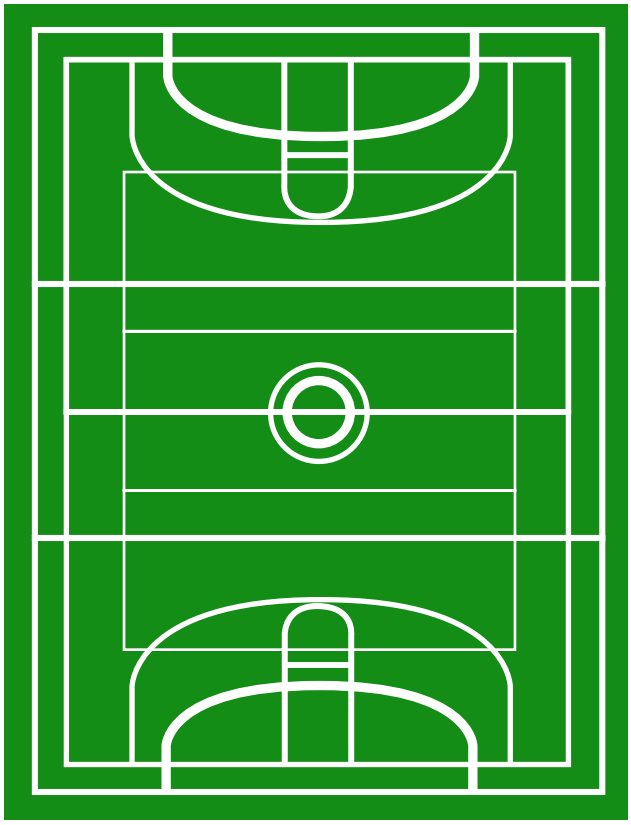
By reversing the playing area and run off area colours, we've created a colour blind friendly court surface.

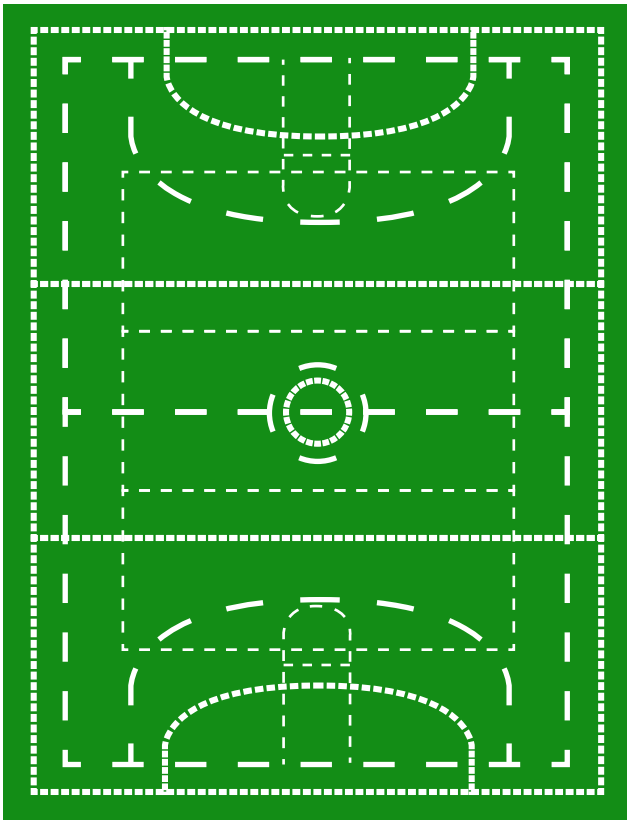
DIFFERING LINES

Differing broken lines or lines of varying thicknesses.

A possible alternative to trying to find a colour blind friendly surface and line marking colour combination is to utilise differing broken lines or lines of varying thicknesses or even a combination of both. Any surface colour or colour combination is possible, the line markings would usually be white unless the court surface was a light/pale colour, in which case black would be best suited.

The benefit of this option is that the different line markings will be clearly discernible to all CVD sufferers in all light conditions, even those with Monochromatic vision. The main drawback to this option is the increased cost. Applying lines of varying thickness or differing broken lines is more labour intensive and will therefore increase the duration of the surface application and the overall cost.





CONCLUSION

As this guide demonstrates, it's not at all difficult to design sports surfacing for the colour blind. It's simply a matter of a little research and forethought when choosing colour combinations. This is also true when it comes to the design of stadiums, sports halls, uniforms, balls, nets, flags, training aids and most other required components of any sporting activity. While this manual has been produced for sports surfacing design, the information supplied within is just as applicable to all of the above.

- ✓ Choose your contrasting colours carefully.
- ✓ Keep your colour palette limited to 2 or 3 colours where possible.
- ✓ Use methods other than colour coding to ensure flags and signage are clearly visible.
- ✓ Use textures and/or patterns to show contrast, instead of colour.
- ✓ Choose a ball colour that CVD players and spectators can easily see against the playing surface colour.
- ✓ Choose team and referee uniform colours that CVD sufferers can differentiate between or design uniforms to be discernible through methods other than colour.
- ✓ Do a little research, make a little effort. It really is that easy.

If you'd like support or further information on Colour Blindness please visit the below:

COLOUR BLIND AWARENESS

www.colourblindawareness.org

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Proudly produced by Grassports Australia (QLD) in conjunction with Colour Blind Awareness (UK)

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