Problem 1)

In[1]:=
```
M = UnitConvert[sodium ELEMENT [atomic mass], "Kilograms"]; StringForm["M = ``", M]
λ = Quantity[589, "nanometers"];
k = 2 π / λ; StringForm["k = ``", UnitConvert[k, "inverse nm"] // N]
p = ħ k; StringForm["p = ``", UnitConvert[p, "Kg m/s"] // N]
v = p / M; StringForm["v = ``", UnitConvert[v, "cm/s"]]
```

Out[1]= M = $3.81754100 \times 10^{-26}$ kg

Out[3]= k = 0.0106675 /nm

Out[4]= p = 1.12497×10^{-27} kg m/s

Out[5]= v = 2.94684318 cm/s

In[6]:=
```
λ' = 2 π c / (2 π c / λ - k v); StringForm["Doppler shifted frequency λ' = ``. So, Δλ = ``", λ', λ' - λ]
```

Out[6]= Doppler shifted frequency λ' = 589.0000000578964075 nm . So, Δλ = $5.78964075 \times 10^{-8}$ nm

Problem 2)

In[7]:=
```
γ2 = 2 π Quantity[10, "MHz"];
T = ħ γ2 / (4 k); StringForm["T_D = ``", UnitConvert[T, "μK"] // N]
StringForm["T_R = ``", UnitConvert[p^2 / (M k), "μK"]]
```

Out[8]= T_D = 119.981 μK

Out[9]= T_R = 2.40112338 μK

Problem 3)

In[30]:=
```
Ω0 = 2 π Quantity[20, "MHz"];
v = Quantity[200, "m/s"];
λ = Quantity[628, "nm"];
δ' = Quantity[1, "GHz"];
M = Quantity[23, "amu"];
γ' = γ2/2 Sqrt[1 + 2 Ω0^2/γ2^2];
β = ħ k^2 Ω0^2 γ2 δ / (2 (δ^2 + (γ')^2)^2);
F = v β;
```

In[29]:=
```
{maxForce, detuning} = Maximize[{F, {-δ' < δ < δ'}}, δ];
```

In[44]:=
```
StringForm["A maximum force of `` is achieved by δ = ``",
 UnitConvert[maxForce, "aN"] // N,
 UnitConvert[δ /. detuning, "MHz"] // N]
StringForm["This force produces an acceleration of ``",
 maxForce / M // UnitConvert]
```

Out[44]= A maximum force of 0.461906 aN is achieved by δ = 54.414 MHz

Out[45]= This force produces an acceleration of 1.209418168×10^7 m/s^2

Problem 4)