Answers

Grade 11 Physics **Additional Friction Problems**

These problems are a little more complex and require you to review the use of the Famous Five Equations for uniform acceleration!!

CAUTION: Things may get a little ROUGH !!

1. Nemo, the student, passes his calculator to his neighbour, Bruce, by giving the calculator a push so that it slides across the desk moving with an initial velocity of 1.8 m/s forward. The calculator has a mass of 350 g. The coefficient of friction between the desk and the calculator is 0.24. The calculator travels 0.45 m across the desk before it is caught by Bruce.
   a) Draw a freebody diagram for the calculator and find the net force on the calculator.
   b) Find the acceleration of the calculator as it slides along.
   c) Find the final velocity of the calculator when it reaches Bruce.

a) up, −B, F+, down

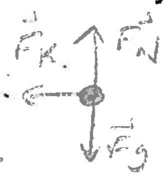
$\mu_K = 0.24$

$m = 350g = 0.350 kg$

$\vec{F}_N$?

$\vec{F}_K$?

F_{net}?



motion → [F]

Vert: Forces balanced

$F_N = F_g$

$F_N = mg$

Hor: Forces unbalanced

$\vec{F}_{Net} = \vec{F}_K$

$= \mu_K F_N$

$= \mu_K mg$

$= (0.24)(0.350 kg)(9.8 m/s^2)$

$= 0.8232 N$ [BKwd]

b) $\vec{a}$?

$\vec{F}_{net} = m\vec{a}$

$\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{0.8232 N [B]}{0.350 kg}$

$= 2.352 m/s^2 [B]$

$\vec{V}_1 = 1.8 m/s [F]$

$\Delta\vec{d} = 0.45 m [F]$

c) $\vec{V}_2 = ?$

$\Delta\vec{d} = \frac{\vec{V}_2^{\,2} - \vec{V}_1^{\,2}}{2\vec{a}} \rightarrow V_2 = \sqrt{V_1^2 + 2a\Delta d} = \sqrt{(1.8 m/s)^2 + 2(-2.352 m/s^2)(0.45 m)}$

$= 1.0598 m/s \simeq 1.1 m/s [F]$

2. A child is sitting on a toboggan while her mother pulls the toboggan along flat, snow covered ground with an applied force of 75.0 N west. The child and her toboggan have a combined mass of 42.0 kg. If the coefficient of friction between the toboggan and snow is 0.12, find:
   a) The net horizontal force on the toboggan.
   b) The acceleration of the toboggan.
   c) If it started from rest, find the velocity of the toboggan after 2.0 seconds.

W, + up + E, − down

a)

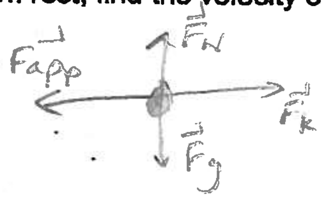
$m = 42.0 kg$

$\vec{F}_{app} = 75.0 N [W]$

$\mu_K = 0.12$

F_{net}?

motion ←



Vert: Forces balanced

$F_N = F_g = mg$

Hor: F_{net}?

$F_K = \mu_K F_N$

$= \mu_K mg$

$\vec{F}_{net} = \vec{F}_{app} + \vec{F}_K$

$= 75.0 N - (0.12)(42.0 kg)(9.8 m/s^2)$

$= 25.608 N [W]$

$\simeq 26 N [W]$

b) $\vec{a}$?

$\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{25.608 N [W]}{42.0 kg}$

$= 0.6097 m/s^2 [W]$

$= 0.61 m/s^2 [W]$

c) $\vec{V}_2$?

$\vec{V}_1 = 0.0 m/s$

$\Delta t = 2.0 s$

$\vec{V}_2 = \vec{V}_1 + \vec{a}\Delta t$

$= 0.0 + (0.6097 m/s^2)(2.0 s)$

$= 1.219 m/s [W] \simeq 1.2 m/s [W]$

Answers:	1. a) 0.82 N [B]	b) 2.4 m/s² [B]	c) 1.1 m/s [F]
	2. a) 26 N [W]	b) 0.61 m/s² [W]	c) 1.2 m/s [W]

Section 5.4

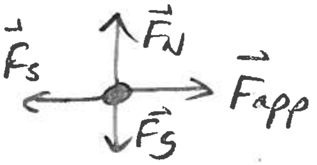
Textbook Friction Problems HW: pg 152 #5, 6, 7, 11

1/2

5) $m = 8.0\,kg$

$\vec{F}_{app} = 31.\,N\ [F]$

$\mu_s = ?$



Vert: Forces balanced

$F_N = F_g = mg$

HoR: Forces balanced

* just as it starts to move

$F_{s_{max}} = F_{app} = 31.\,N$

Solving for μ_s:

$$\therefore \mu_s = \frac{F_{s\,max}}{F_N} = \frac{31.\,N}{(8.0\,kg)(9.80\,m/s^2)} = 0.3954 \simeq \underline{\underline{0.40}}$$

$\therefore$ the coefficient of static friction between the steel slider and rail is 0.40.

6) $\vec{\Delta d} = 18\,m\ [F]$

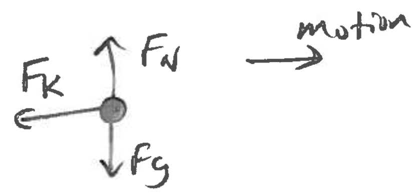
$\mu_K = 0.8$ (Rubber tire on dry asphalt)

$\vec{F}_K = ?$

$V_2 = 0.0\,m/s$

$V_1 = ?$

$\vec{a} = ?$



Vert: Forces balanced $\quad F_N = F_g = mg$

Hor: Forces unbalanced $\quad F_{Net} = F_K = \mu_K F_N = \mu_K mg$

$$\therefore \boxed{F_{Net} = \mu_K mg}$$

Find acceleration: $\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{\mu_K \cancel{m} g}{\cancel{m}} = \mu_K g$

$= (0.8)(9.80\,m/s^2)$

$= 7.84\,m/s^2$

Find $\vec{V}_1$:

$$\Delta d = \frac{V_2^2 - V_1^2}{2a}$$

$$V_1 = \sqrt{V_2^2 - 2a\Delta d}$$

$$V_1 = \sqrt{0.0 - 2(-7.84\,m/s^2)(18\,m)}$$

$$\vec{V}_1 = 16.8\,m/s\ [F]$$

Convert to km/h:

$$\frac{16.8\,m}{s} \times \frac{3600\,s}{h} \times \frac{1\,km}{1000\,m} = 60.48\,km/s \simeq 60.\,km/h\ [F]$$

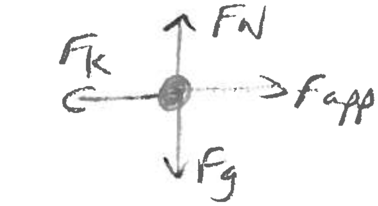
$\therefore$ the driver was not speeding as $60.\,km/h < 80\,km/h$

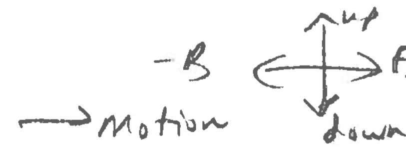
7] $m = 12\ kg$

$F_{app} = 82N$

$\mu_k = 0.42$

a)





b) Vert: $F_N = F_g$

$F_N = mg$

$F_K = \mu_k F_N$

$= \mu_k mg$

$= (0.42)(12kg)(9.80 \, m/s^2)$

$= 49.392\ N\ [B]$

$\approx 49\ N\ [B]$

HoR: $\vec{F_{net}} = \vec{F_{app}} + \vec{F_k}$

$F_{net} = 82N - \mu_k F_N$

$F_{net} = 82N - (0.42)(12\ kg)(9.80\ m/s^2)$

$F_{net} = 32.608\ N\ [F]$

$\vec{F_{net}} \approx 33\ N\ [F]$

c) $\vec{a}$? $\vec{a} = \frac{\vec{F_{net}}}{m} = \frac{32.608N\ [F]}{12\ kg} = 2.717\ m/s^2\ [F] \approx 2.7\ m/s^2\ [F]$

d) To move at constant velocity Horizontal forces must be balanced

$F_k = F_{app}$

$\therefore F_{app} = 49\ N\ (F)$

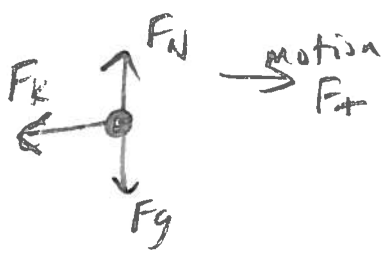
11] $m = 400.\ kg$

$\vec{V_1} = 4.0\ m/s\ [N]$

$\mu_K = 0.0500$

$\Delta \vec{d} = ?$

$\vec{V_2} = 0.0\ m/s$



Vert: $F_N = F_g = mg$

Hor: $F_{net} = F_K$

$= \mu_K F_N$

$= \mu_K mg$

$\therefore \vec{F_{net}} = (0.0500)(400.\ kg)(9.80\ m/s^2)$

$= 196.\ N\ [B]$

Solve for acceleration:

$\vec{a} = \frac{F_{net}}{m} = \frac{196.N\ [B]}{400.\ kg} = 0.490\ m/s^2\ [B]$

Solve for distance travelled:

$\Delta \vec{d} = \frac{\vec{V_2}^2 - \vec{V_1}^2}{2\vec{a}} = \frac{0.0 - (4.0m/s)^2}{2(-0.490\ m/s^2)} = 16.327\ m\ [F] \approx 16\ m\ [F]$