General Physics: Class Exam 2

16 October 2023

Name: Solution. **Total:** /70

Instructions

- There are 8 questions on 6 pages.
- Show your reasoning and calculations and always explain your answers.

Physical constants and useful formulae

$g = 9.80\,\mathrm{m/s^2}$ $G = 6.67 \times 10^{-11}\,\mathrm{Nm^2/kg^2}$

Question 1

A sleepy 4.5 kg cat lies on a very smooth horizontal floor. The cat is at rest and then a child pushes with a horizontal force on the cat for the next 3.0 s. At the end of this period the cat moves with speed 6.0 m/s. Determine the force exerted by the child on the cat, ignoring friction and air resistance.

initial ① final ②

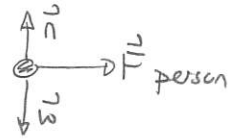
$t_i = 0\,s$ $t_f = 3.0\,s$

$v_i = 0\,m/s$ $v_f = 6.0\,m/s$

+1 $v_f = v_i + a\Delta t$

+3 $6.0\,m/s = 0\,m/s + a\,3.0\,s$

$\Rightarrow a = 2.0\,m/s^2$

+2 

+1 $\Sigma F_{ix} = ma_x \Rightarrow F_{person} = ma_x$

$\Rightarrow$ need acceleration

+3 $F_{person} = 4.5\,kg \times 2.0\,m/s^2$

$= 9.0\,N$

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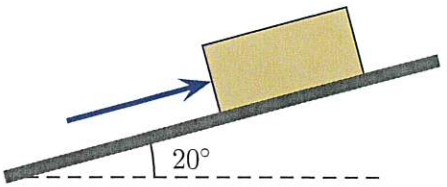
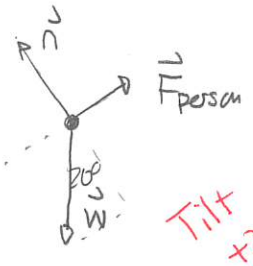
Question 2

A 40 kg box lies on a frictionless inclined ramp. You push parallel to the ramp against the block.



a) Determine the force which which you must push to keep the box at rest.

+2



Tilt +2

$\Sigma F_{ix} = ma_x = 0$
$\Sigma F_{iy} = ma_y = 0$ } since at rest] +1

$W = mg = 40kg \times 9.8 m/s^2 = 392N$] +1

$W_x = -W\sin 20° = -134N$
$W_y = -W\cos 20° = -368N$] +2

	x	y
$\vec{W}$	-134N	-368N
$\vec{n}$	0	n
$\vec{F}_p$	F_p	0

Then $\Sigma F_{ix} = 0$

$\Rightarrow -134N + F_p = 0 \Rightarrow F_p = 134N$

Require 134N] +2

b) Suppose that you push the block so that it moves up the ramp at constant speed. Which of the following is true about the force *while the block moves at constant speed?* Ignore air resistance.

+4

i) The force you exert is larger than the force needed to keep the block at rest.
ii) The force you exert is smaller than the force needed to keep the block at rest.
iii) The force you exert is the same as the force needed to keep the block at rest.

The acceleration is again zero. The same analysis as above.

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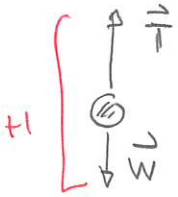
Question 3

A 0.30 kg ball is suspended from a string and is raised. It moves vertically upward with a constant acceleration of 4.0 m/s^2. Determine the tension in the string, ignoring air resistance.



$\Sigma F_{iy} = ma_y$] +1

$T - w = ma_y$

(+3)

$w = mg$

$= 0.30\,kg \times 9.8\,m/s^2$

$= 2.94\,N$ +1

(+2)

$T - 2.94N = 0.30kg \times 4.0\,m/s^2$

$T - 2.94N = 1.2\,N$

$T = 1.2N + 2.94N \Rightarrow$ $T = 4.14N$

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Question 4

A cart slides horizontally with decreasing speed to the right. Which of the following (choose one) is true while this happens?

Accel is ←

⇒ net force is ←

i) The net force on the cart is zero.
ii) The net force on the cart is down.
iii) The net force on the cart is to the right.
iv) The net force on the cart is to the left.

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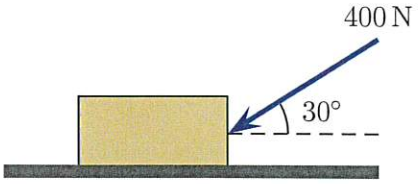
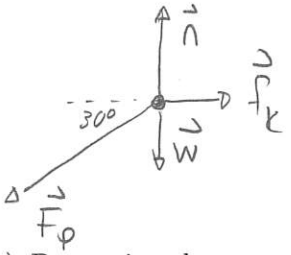
Question 5

A 50 kg box moves left along a horizontal surface. A person pushes on the box with a force of magnitude 400 N and which is directed 30° below the horizontal. The coefficient of kinetic friction between the box and the floor is 0.20.



a) Draw a free body diagram for the box.



+2

b) Determine the normal force exerted by the surface on the box.

$\sum F_{ix} = ma_x$

$\sum F_{iy} = ma_y = 0$] +1

$w = mg = 50\text{kg} \times 9.8\text{m/s}^2 = 490\text{N}$ +1

$f_k = \mu_k n = 0.20\,n$ +1

$F_{px} = -F_p \cos 30^\circ$

$= -400\text{N} \cos 30^\circ = -346\text{N}$

$F_{py} = -F_p \sin 30^\circ$

$= -400\text{N} \sin 30^\circ = -200\text{N}$] +3

	x	y
W	0	-490N
n	0	n
F_p	-346N	-200N
f_k	f_k	0

+2

$\sum F_{iy} = 0 \Rightarrow -490\text{N} - 200\text{N} + n = 0$

$\Rightarrow n = 690\text{N}$] +2

Question 5 continued ...

c) Determine the acceleration of the box.

$\Sigma F_{ix} = ma_x$

$-346\,N + 690\,N \times 0.20 = 50kg\ a_x$

$\Rightarrow 50kg\ a_x = -208\,N$ +4

$\Rightarrow a_x = -4.2\ m/s^2$

(left)

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Question 6

Two objects, each with mass 15.0 kg, are held fixed at a distance of 0.40 m apart.

a) Determine the magnitude of the gravitational force that one exerts on the other.

$F_g = G\frac{m_1 m_2}{r^2} = 6.67 \times 10^{-11}\,Nm^2/kg^2 \quad \frac{15.0kg \times 15.0kg}{(0.40m)^2}$ +2

+1 $= 9.4 \times 10^{-8}\,N$

b) The distance between the objects is decreased so that the force exert by one on the other is four times what it had been. Which of the following (chose one) is true? +3

i) The separation is now 0.30 m.
ii) The separation is now 0.20 m.
iii) The separation is now 0.10 m.
iv) The separation is now 0.05 m.

If r is halved then $\frac{1}{r^2}$ 4 times

Thus r must halved.

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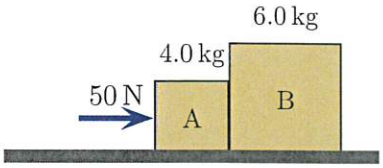
Question 7

Two crates move right along a horizontal frictionless surface. A person pushes horizontally to the right on crate A with a 50 N force. The two crates move to the right. Left $F_{\text{A on B}}$ be the force that A exerts on B. Which of the following (choose one) is true?



i) $F_{\text{A on B}} = 50\,\text{N}$.

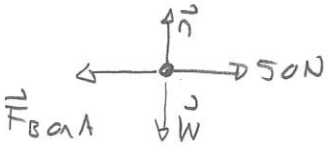
ii) $F_{\text{A on B}} > 50\,\text{N}$.

iii) $F_{\text{A on B}} < 50\,\text{N}$.

Box A accelerates right

$\Rightarrow F_{B\text{ on }A} < 50N$

$\Rightarrow F_{A\text{ on }B} < 50N$



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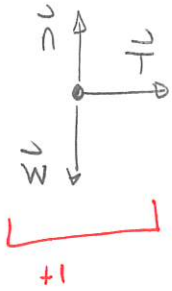
Question 8

A 0.080 kg ball is tied to the end of a 1.5 m long string. The string is held at one end and the ball is made to swing in a horizontal circle (it is supported by a horizontal frictionless surface). The string will break once the tension becomes larger than 2.5 N. Determine the maximum speed at which the ball can move without the string breaking.



+1

$\vec{a}$

$\sum F_{ix} = ma$ +1

$a = \frac{v^2}{r}$ +1

$\Rightarrow T = \frac{mv^2}{r}$ +2

$\Rightarrow 2.5N = \frac{0.080kg}{1.5m} v^2$

$\Rightarrow \frac{2.5N \times 1.5m}{0.080kg} = v^2$

$\Rightarrow v^2 = 46.9 m^2/s^2$

$\Rightarrow v = \sqrt{46.9 m^2/s^2} \Rightarrow v = 6.8 m/s$ +3

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