Validation

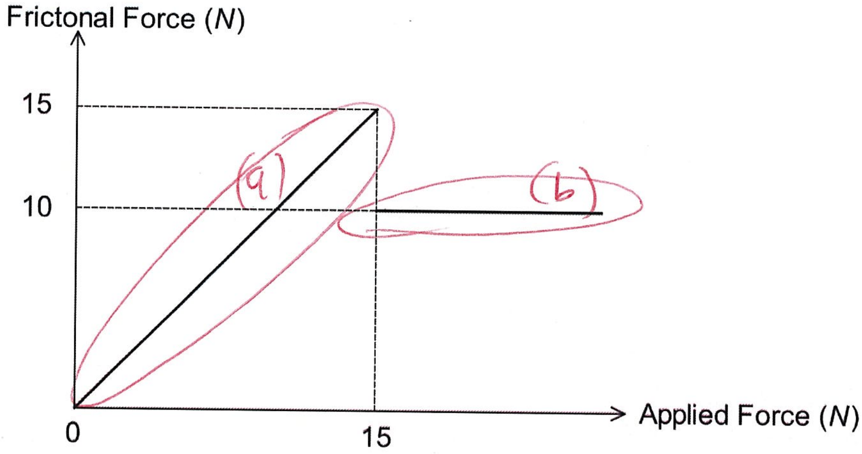
NAME: SOLUTIONS

Total Marks: 34 *Time Allowed: 45 minutes*

(Formula sheet, research notes and scientific calculator permitted)

Question 1 **(4 marks)**

The following graph shows the friction on an object (that is initially stationary) as the applied horizontal force on the object changes:



(a) Circle the part of the graph that corresponds to the object being stationary and label it (a). ✓ [1] 1

(b) Circle the part of the graph that corresponds to the object moving and label it (b). ✓ [1] 1

(c) Start the value of the force of friction on the object when it is moving. [1]

10 N ✓ 1

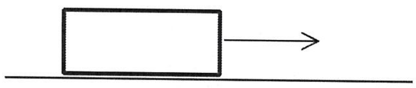
(d) State the value of the force needed to make the object move. [1]

15 N ✓ 1

4

Question 2 **(16 marks)**

Max is attempting to push a heavy box along a rough surface.



(a) Explain why Max's task is made easier if his friend Minnie applies an upward force to the box. [2]

The upward force reduces the net force of the box on the surface.
Hence the static friction is reduced ($F = \mu N$) and Max need apply a smaller force to overcome it.

2

Max applies a constant force of 180.0 N and finds that the box initially accelerates at 0.144 ms^{-2}. The box has a mass of 25.0 kg and Minnie is no longer assisting him.

(b) Find the coefficient of static friction that applies in this case. [5]

$$\text{Net force} = ma = 25 \times 0.144 = 3.6\ \text{N}$$

$$\therefore F_{friction} = 180 - 3.6 = 176.4\ \text{N}$$

$$F = \mu m g$$

$$176.4 = \mu \times 25 \times 9.8$$

$$\therefore \mu = \underline{0.720}$$

5

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(c) Assuming that the coefficient of dynamic friction is 80.0% of the coefficient of static friction, determine the box's acceleration as it continues to move. [5]

$\therefore \mu_d = 0.8 \times 0.72 = 0.576$ ✓

$F = \mu m g$

$= 0.576 \times 25 \times 9.8$ ✓

$= 141.12\ N$ ✓

$\therefore$ Net force $= 180 - 141.12$

$= 38.88\ N$ ✓

$\therefore$ accel. $= \frac{F}{m}$

$= \frac{38.88}{25}$

$\approx 1.56\ ms^{-2}$ ✓

5

(d) If Max lets go of the box when its speed is 2.80 ms^{-1}, how far will it slide before coming to rest? [4]

$F = 141.12$ ✓

$E_K = \frac{1}{2} m v^2$

$= 0.5 \times 25 \times 2.8^2$

$= 98\ J$ ✓

$W = Fs$

$98 = 141.12 \times s$ ✓

$\therefore s \approx 0.694\ m$ ✓

4

[OR use $v^2 = u^2 + 2as$]

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Question 3 **(6 marks)**

A certain surface has a coefficient of static friction of 0.640 and a coefficient of dynamic friction of 0.480.

(a) Calculate the least initial force required to move an object of mass 2.30 kg on the surface. [2]

$F = \mu_s mg$

$= 0.64 \times 2.3 \times 9.8$ ✓

$\approx \underline{14.4 \text{ N}}$ ✓ 2

(b) Calculate the minimum force required to sustain the movement of the object in part (a). [2]

$F = \mu_K mg$

$= 0.48 \times 2.3 \times 9.8$ ✓

$\approx \underline{10.8 \text{ N}}$ ✓ 2

Assume the object in part (a) is moving.

(c) What will happen to the object if the force now applied is less than the value calculated in part (b)? [1]

The object will decelerate and come to rest. ✓

1

(d) What will happen to the object if the force now applied is more than the value calculated in part (b)? [1]

The object will accelerate. ✓ 1

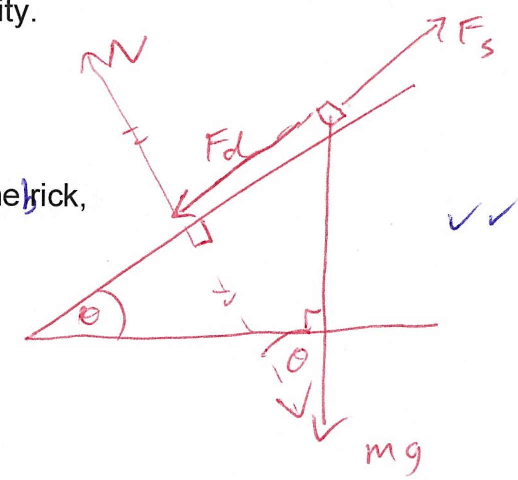
/6

Question 4

(8 marks)

Ben places a brick on an inclined plank of wood. The coefficient of static friction in this situation is μ.

Let m = the mass of the brick,
θ = the angle of the plane to the horizontal,
and g = the acceleration due to gravity.



(a) In terms of μ, m, g and θ, determine

(i) the normal reaction force of the plank on the brick,

$N = mg\cos\theta$

(ii) the force of static friction on the brick,

$F_s = \mu mg\cos\theta$

5

(iii) the brick's weight component down the plane. [5]

$F_d = mg\sin\theta$

(b) Hence show that, if the brick is not to slide down the plane, the maximum value of θ is given by $\tan\theta = \mu$. [3]

$\therefore F_s = F_d$

$\mu mg\cos\theta = mg\sin\theta$

$\mu = \dfrac{\sin\theta}{\cos\theta}$

3

i.e. $\mu = \tan\theta$

- End of Questions -

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