A 50 kg girl wearing a 10 kg backpack is exercising her dog, and to give him a better run she decides to accompany him on skates. While she is stopped to take a phone call, the dog sees a squirrel and starts running quickly after it. The girl gets pulled along, with the leash now making an angle of 30 degrees above the horizontal. The leash exerts a horizontal force on the girl of 80 N as she begins to roll off.

1. What is the total tension in the leash?
(A) 0 N  (B) 15 N  (C) 69 N  (D) 80 N  (E) 92 N  (F) 160 N

2. While the dog is accelerating (and pulling the girl), the force of leash on the dog (A) is exactly the same as the dog on the leash (B) is greater than the dog on the leash (C) is less than the dog on the leash

3. If she had dropped her backpack when the squirrel chase began, (A) she would have had greater acceleration (B) she would have had less acceleration (C) she would have had the same acceleration because the force is the same

4. She starts to drag her toes to offset the dog's pull. When her friction force finally equals the force of the leash (A) she stops (B) she continues with constant velocity (C) she continues with constant acceleration (D) she goes backwards (E) she gradually slows down

FREE RESPONSE (three questions, 6 points each) SHOW ALL WORK IN THE SPACE BELOW. NO CREDIT FOR AN ANSWER, EVEN IF CORRECT, WITHOUT CLEAR WORK OR AN EXPLANATION.

5. What is the acceleration of the girl (and backpack) as the dog first heads off after the squirrel?

6. While she was first accelerating, (before she drags her feet), how fast was she going after a time of 0.3 s.

7. How far has the dog dragged her in that time?

5. \[ a = \frac{\sum F}{m} = \frac{80 \text{ N}}{(50 \text{ kg} + 10 \text{ kg})} = 1.3 \text{ m/s}^2 \]

6. \[ a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{1.3 \text{ m/s}^2} \]

7. \[ s = v_0 t + \frac{1}{2} \Delta t \]

For all 3 parts (5, 6 and 7)
On the moon the acceleration of gravity is $1/6$ that of Earth. Some years in the future, Hugo, a Canadian lunar colonist is planning recreation with his favorite sport, ice hockey. He orders a puck from Amazon (on Earth) which its website says has a mass of 0.17 kg. The ice on which they are going to play has a coefficient of friction between puck and ice of 0.1.

8. What is the mass of the puck on the moon?
   (A) 0 kg  (B) 0.027 kg  (C) 0.16 kg  (D) 0.17 kg  (E) 1.02 kg

9. What is the weight of the puck on the moon?
   (A) 0 N  (B) 0.044 N  (C) 0.278 N  (D) 1.67 N  (E) 9.8 N

10. If the force of friction of the puck on ice on Earth is $f$, the friction of the puck on lunar ice (assuming the ice is the same), is (A) exactly $f$  (B) slightly more than $f$  (C) $f/6$  (D) $f/36$  (E) $6f$

11. Hugo has hit a slap shot that makes the puck rise up off the ice and leave the stick with a velocity of $v$ on Earth. In the lunar indoor rink, his slapshot will have a velocity of (A) $v/6$  (B) $v$  (C) $6v$  (D) $36v$

12. The force that the puck exerts on the moon is (A) zero  (B) too small to measure  (C) equal to its lunar weight  (D) $1/6$ of its lunar weight

13. If the puck were to be dropped from a great height above the airless lunar surface, it would reach terminal velocity (A) never  (B) eventually, but in a time longer than on Earth  (C) just as quickly as on Earth  (D) much sooner than it does on Earth.

FREE RESPONSE (one question, 6 points) SHOW ALL WORK IN THE SPACE BELOW. NO CREDIT FOR AN ANSWER, EVEN IF CORRECT, WITHOUT CLEAR WORK OR AN EXPLANATION.

14. What is the Mass of the moon, given that its radius is $1.7 \times 10^6$ m?

$$F = \frac{G M m}{r^2}$$

$$= m a$$

Thus

$$a = \frac{G M}{r^2}$$

and

$$M = \frac{a r^2}{G} = \frac{(g/6)r^2}{G}$$

$$= \frac{(4.8 \text{ m/s}^2)(1.7 \times 10^6 \text{ m})^2}{6 \times 6.67 \times 10^{-11} \text{ N} \text{m}^2/\text{kg}^2}$$

$$= 7.1 \times 10^{22} \text{ kg}$$
A short railroad train consists of a small locomotive, followed by a loaded passenger, and then a freight car at the end. The locomotive and cars each have a total mass of 150x10^3 kg. The train starts from rest, and the locomotive exerts a force of 3x10^5 N. Only the locomotive exerts a force on the tracks pulling the train forward.

15. What is the acceleration of the whole train?
(A) 0.2 m/s^2 (B) 0.67 m/s^2 (C) 2. m/s^2 (D) 6. m/s^2 (E) 9.8 m/s^2

16. Which graph best shows the velocity as a function of time?
(A) (B) (C) (D)

17. How much force is exerted on the freight car (at the end) while the train is accelerating as above?
(A) 0 N (B) 1x10^5 N (C) 2x10^5 N (D) 3x10^5 N (E) 4x10^5 N

18. How much force does the locomotive exert on the passenger car while the train is accelerating as above?
(A) 0 N (B) 1x10^5 N (C) 2x10^5 N (D) 3x10^5 N (E) 4x10^5 N

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19. Suppose the train had started its motion on a small uphill slope of 5°. If you neglect friction, what would be the net force on the train?

\[ \text{we need } w_{\parallel}, \text{ weight parallel to the slope.} \]

\[ w_{\parallel} = w \sin 5° \]

\[ = mg \sin 5° \]

\[ = 3 \times 150 \times 10^3 \text{ kg} \times 9.8 \text{ m/s}^2 \times 0.087 \]

\[ = 3.2 \times 10^5 \text{ N} \]

\[ \text{Train only exerts } 3 \times 10^5 \text{ N} \]

\[ \text{Net is down hill:} \]

\[ F - w_{\parallel} = -8.4 \times 10^4 \text{ N} \]

\[ \text{The slope of } 3°, \text{ however, gives} \]

\[ F - w_{\parallel} = 6.9 \times 10^4 \text{ N} \text{ UPHILL}. \]